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Collision Of Nanotechnology On Human Health And The Environment In South Asia: An Overview

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Abstract

Nanotechnology is a ‘multidisciplinary’ as well as an ‘interdisciplinary’ area of inquiry and application. The broad spectrum of applications that nanotechnology is and will be catering to speaks of its omnipresence. Be it in agriculture, energy, electronics, medicine, healthcare, textiles, transport, construction, cosmetics, water treatment etc., nanotechnology finds a role to play or rather a ‘defining role’ to play, as suggested by many scholars worldwide. All around the world, nanotechnology is being promoted as a technological revolution that will help solve an array of problems. According to the current hype, nanotechnology promises to provide new ways of solving some of the Asia-Pacific Region’s chronic challenges, such as treating tuberculosis and malaria, making water drinkable, conserving food, and diversifying energy sources, among other hosts of applications. However, the potential risks and social implications of this new technology are not often highlighted in this paper. The overall level of awareness and capacity to address these issues remains very low, in both civil society and government, and prevents these actors from playing their social role in ensuring the public good. The present review based article enlighten impact of nanotechnology on human health and environment in south Asian countries

Key Words: Application, Challenges, Civil Society, Energy, Public, Technology and Tuberculosis

1) Introduction:

A number of observers have catalogued societal issues that emerging nanotechnologies may raise. The early treatment by ‘ Roco and Bainbridge’ (2001), for example, includes implications of economic, political, educational, medical, environmental, and national security import, as well as potential consequences for privacy and global equity. ‘Moore (2002)’ divides the implications of nanotechnology into three categories: social, including environmental, health, economic, and educational; ethical, including academic-industry relations, abuse of technology, social divides, and concepts of life; and legal, including concepts of property, intellectual property, privacy, and regulation.

Research on nanotechnology and increased commercialization of products containing engineered nanomaterials (generally called nanoproducts), is currently happening in the ‘Asia-Pacific’ Region (e.g., Thailand, China, India, Korea, Japan, Australia, and many other countries). In several countries in the region, nanotechnology has been declared a strategic sector of scientific and technological development. To achieve the strategic goals, public funds have been or are being used to encourage nanotechnology development through the establishment of research networks and research centres (Adidas, 2008). While many countries in the Asia-Pacific Region have established national nanotechnology initiatives, actual investments in this area vary greatly from country to country. Japan, China, and South Korea have all heavily invested in nanotechnology research and development, with, for instance, China spending USD$ 1.3 billion in 2011 (Colman BP, Arnaout CL, Anciaux S, Gunsch CK, Jr HM. 2013)

Even though potential health and environmental risks of engineered nanomaterials are scientifically documented and numerous uncertainties remain, the public funds dedicated to evaluating these risks are extremely low. As a consequence, the current policies in regard to this technology are far from precautionary as the products enter the market unregulated and unlabeled, neither guaranteeing safety of the product nor the provision of information to the consumer. Conscious of the lack of information, regulations, and supervision of nanotechnology, governmental delegations, experts, and representatives of civil society organizations from around the world agreed to address nanotechnologies and manufactured nanomaterials as an emerging issue in the context of the Strategic Approach for International Chemical Management (SAICM)

2) The Role of SAICM:

SAICM is a voluntary agreement of the international community envisaged to serve as a global framework in which to discuss methods of cooperation and specific actions that can be taken in relation to achieving safe, responsible, and sustainable management of chemicals. Since 2009, nanotechnologies and manufactured nanomaterials are addressed as an emerging policy issue. Accordingly, regional reunions and general meetings have adopted several resolutions and recommendations. At the Third International Conference on Chemical Management (ICCM3) held in September 2012 in Nairobi, Kenya, specific activities related to nanomaterials were added to SAICM Global Plan of Action, as well as a resolution recommending, among other measures, the development of international technical and regulatory guidance and training materials for the sound management of manufactured nanomaterials (Colman BP, Arnaout CL, Anciaux S, Gunsch CK, Jr HM. 2013).

- provide an overview of nanotechnology development in the Asia-Pacific Region;
- Introduce the social, environmental, and health implications of nanotechnology for workers and consumers in this region; and
- To stimulate and strengthen stakeholders’ participation in the global and national discussions on the actions to be implemented by governments, industry, and civil society to lay out a precautionary environment for the safe development of this technology (Bhati M. 2013)

Nanotechnology is the manipulation of matter at a molecular and atomic scale. It involves the artificial combination of atoms and molecules to create particles and structures with functions different from that of the same material at a larger scale (Hartmann NB, Baun A. 2010).

3) Status of Nano- Technology in Asia-Pacific:

The Asia-Pacific Region is a huge geographic area, which comprises about 22 percent of the global land area and almost 60 percent of the global population.

It includes countries in South, North, Insular, South-East Asia and the Oceania-South Pacific Region. From a socio-political point of view, i.e. the political economic systems, types of societies, cultures, and underlying values, the Asia- Pacific Region is extremely diverse.

Most countries in the region follow a broadly capitalist economic system, albeit with considerable variation in its interpretation. The private sector in most countries plays an important role with varying degrees of governmental involvement in directing the economy and, by implication, guiding technology and research.

On a microeconomic level, most people living in this region, with perhaps the exception of the industrialized countries, are engaged in the subsistence sector (Garber, C. 2006)

Additionally, most countries in the region have at least a small urban elite or even a developing middle class, and overall urbanization is a developing trend. The extent and nature of industrial development in a country will determine to some extent the kind of nanotechnologies that are important to its public and private sectors and the extent of research activities in nanotechnologies

Table 1: Asia Pacific Region Countries

South Asia	**Continental South East Asia**	**North East Asia**	**Insular South East Asia**	**Oceania South Pacific**
Bangladesh	Cambodia	**China**	Brunei/Darus-salam	**Australia**
Bhutan	Laos	**Japan**		**New Zealand**
India	Myanmar/ Burma	Korea, DPR	**Indonesia**	Pacific Island Nations
Maldives	**Thailand**	**Korea, Rep**	**Malaysia**	
Nepal		Mongolia	**Philippines**	
Pakistan	**Vietnam**	**Taiwan**	**Singapore**	
Sri Lanka				

Key nanotechnology areas that are thought to be of most potential benefit for the Asia-Pacific Region include:

- information and communication;
- healthcare (diagnostic, cancer treatment, and biosensors);
- environmental protection (reduce carbon dioxide emissions);
- reduction of energy consumption;
- purification, protection, and production of drinking water;
- renewable energies; and
- Agriculture and food security/safety.

4) Institutional Setting on Nano Science:

- There are a number of regional networks, including the Asia Nano Forum (ANF), which includes Australia, China, Hong Kong, Iran, India, Indonesia, Korea, Japan, Malaysia, New Zealand, Singapore, Taiwan, Thailand, UAE, and Vietnam.
- Other types of public/private partnerships are also relatively commonplace. The Nano Science and Technology Consortium (NSTC), based in India, is an example of a regional industry advocacy organization that engages in support for research, technology transfer, and consultation.
- Regional workshops have been organized on a regular basis, including a workshop in Sri Lanka organized in 2009 by the Asian and Pacific Centre for Transfer of Technology (APCTT).
- The high-level workshop included over 40 local and 20 international participants and focused on promoting innovation in nanotechnology and fostering its industrial application.

- Bilateral and multi-lateral partnerships and exchange programs among various Asia-Pacific countries and Europe, the U.S., or other parts of the world are commonplace and too numerous to detail.

5) Building Capabilities in South Asia:

South Asia or the Indian Subcontinent is densely populated and the home to one fifth of the world population. It includes, for the purpose of this discussion, India, Pakistan, Bangladesh, Nepal, and Sri Lanka.

As part of the larger study "Nanotechnology in South Asia: Building Capabilities and Governing the Technology in India, Pakistan and Sri Lanka, " TERI (India), the National Science Foundation of Sri Lanka, and PINSAT, Preston University, Pakistan organized, in September 2012, a regional dialogue, Nanotechnology Developments in South Asia: Stake holder's Perspective." Stakeholders from academia, industry, and civil society were present. The absence of regulation of nanomaterials and nanotechnology was one of the key issues raised. Lack of R&D partnerships among the countries of South Asia and increased sharing of the information and experiences among countries with different levels of economic development in the region were also identified as major issues.

6) Status in India:

Research and Development:

India is the largest country in the Indian Subcontinent and has a population of over 1.2 billion people. While nanotechnology in India is still a largely government led initiative via publically funded research facilities and universities, industry participation is increasing, especially in the form of public-private partnership. These partnerships have chiefly focused on pharmaceutical/ nano-medicine, textiles, nanocomposites, and agriculture opportunities (see http://nanomission.gov. in).

There are at least 170 institutions and universities involved in nanotechnology research, international nanotechnology conferences are being organized on a regular basis, and there are two Indian scientific periodicals dedicated exclusively to nanotechnology.

Government led nanotechnology initiatives are coordinated via the Department of Science and Technology's (DST) "Mission on Nano Science and Technology" (Nano Mission).

Nano Mission is the primary funding and coordination body for nanoscience and nanotechnology research in India.

The technical programs are guided by the Nano Science Advisory Group (NSAG) and the Nano Applications and Technology Advisory Group (NATAG).

Nano Mission has financed close to 200 projects since 2002 and has also established 'Centres of Excellence (CoE) for Nanoscience and Technology' to develop specific applications. Other government departments supporting research into nanotechnology include the CSIR (Council Additional important institutions involved in supporting nanotechnology research and development include the Department of Biotechnology (DBT),

The Department for Information Technology (DIT),

The Defense Research and Development Organization (DRDO) and its National Program on Micro and Smart Systems (NPMASS),

The Department of Scientific and Industrial Research (DSIR),

The Indian Council of Agricultural Research (ICAR),

The Department of Atomic Energy (DAE),

The Ministry of Communication and Information Technology (MCIT)

The Council of Scientific and Industrial Research (CSIR), An autonomous body under DSIR, has established a range of working groups involved with nanotechnology research at the National Physical Laboratory (NPL),

The Structural Engineering Research Centre (SERC),

The National Institute of Science, Technology and Development Studies (NISTADS),

The National Environmental Engineering Research Institute (NEERI),

The National Chemical Laboratory (NCL),

The Indian Institute of Toxicology Research (IITR) and others

Other public institutions involved with nanotechnology research and development include the various Indian Institutes of Technology (IITs),

The National Research Development Corporation (NRDC) and other institutes of higher education that are, for the most part, publicly funded

The intensity of nanotechnology research, development, and policies varies greatly at the sub-federal level.

For instance, Karnataka, with its capital Bengaluru (Bangalore), seeks to become the leading nanotech state in India.

Andhra Pradesh hosts the ICICI Knowledge Park (IKP) in Hyderabad with research programs in nanotechnologies.

Other notable nanotechnology research centers include the Amrita Centre for Nanosciences (ACNS) in Kochi, Kerala.

Research into water filtration is one of the key flagship activities in Indian nano research with a number of research centers involved. Products are at varying stages of commercialization. ARCI, Hyderabad is field-testing silver nanofilters;

IIT, Chennai has developed nano silver based carbon blocks used in Eureka Phorbes Aquaguard; and Total Gold Nova,

Tata Consultancy Services (TCS),

Tata Chemicals and Titan Industries have developed and are marketing a filter impregnated with nanosilver particles, activated silica, and carbon.

Other institutes are working on carbon nano filters, nano photocatalysts, nanosilver coated alumina catalysts for water filtration, and nano Iron Oxide/ mixed oxide for arsenic removal.

7) International Cooperation and Agencies:

Indian government agencies are involved via the Nanotechnologies Sectional Committee (MTD 33) with the International Organization for Standardization's Technical Committee on Nanotechnologies (ISO/TC 229). International research collaborations are carried out with the EU, China, India, and Russia. These programs seek to promote collaboration between scientists and to establish an electronic archive of nanoscience and nanotechnology publications.

Bilateral cooperative arrangements exist with Germany, Italy, and Taiwan, as well as with China, Brazil, and South Africa to fund targeted research on advanced materials, health care, clean water, and energy. Since 2006, Annual "Nanotechnology Conclaves" are being conducted with annually changing partners, including the U.S., the UK, Japan, Iran, and South Korea.

India, Brazil, and South Africa, as part of the IBSA 'trilateral' developmental initiative, have also formulated a trained bi-lateral collaborative nanotechnology program, which includes research in health, water treatment, and agriculture, as well as education and human resource development. India leads with its flagship project on water purification.

8) NanoTechnology Challenges need to be assessed:

Traditional chemical management defines the risk posed by a substance as a function of a) the hazard characteristics of a specific substance, and b) the exposure to this substance (i.e., risk = hazard x exposure or R=HxE).

When information is lacking on either one of these two elements (the hazardous property of a substance or the level of human or environmental exposure to it), it creates uncertainty with regard to the risk posed by the substance, as defined in traditional chemical management. When converging scientific information points in the direction of hazardous properties but is insufficient to fully characterize the risk, it is often referred to as potential risks. This section will focus on the hazard characteristics of nanomaterials, while the next will focus on exposure pathways (European Environmental Agency 2001).

Historical evidence supported by scientific findings shows that all new technologies come with risks to human health and the environment, and nanotechnology is no exception.

The increasing number of engineered nanomaterials and nano products gives rise to increasing breadth and extent of the potential risks posed to human health and the environment.

For example, engineered nanomaterials are of similar size range as exhaustion particles from engines combustion, and certain carbon nanotubes are in many ways similar to asbestos fibres, substances that are known to cause adverse effects to human health, namely, cancer and asbestosis.

For the last 20 years, diverse stakeholders, such as non-governmental organizations, environmental activists, consumers, trade unions, and other social actors, have raised questions about the risks posed by nanotechnology and manufactured nanomaterials (Jarvis SL, Richmond N. 2011)

Unfortunately, the responses consistently have been that these risks are largely unknown, that it was too early in the technology to evaluate the risks, or even that there were no risks to human health or the environment arising from nanotechnology and manufactured nanomaterials (Deng, X.; Luan, O.; Chen, W.; Wang, Y.; Wu, M.; Zhang, H.; & Zheng, J. 2009).

The uncertainty about nano related risks has not impeded the rapid introduction of nanotechnology products into the market. On the contrary

Most nanotechnology policies put in place in the last 10 years have been largely been geared toards accelerating nanotechnology introduction into the markets with only very limited consideration of precautionary approaches to address the potential risks of this emerging technology.

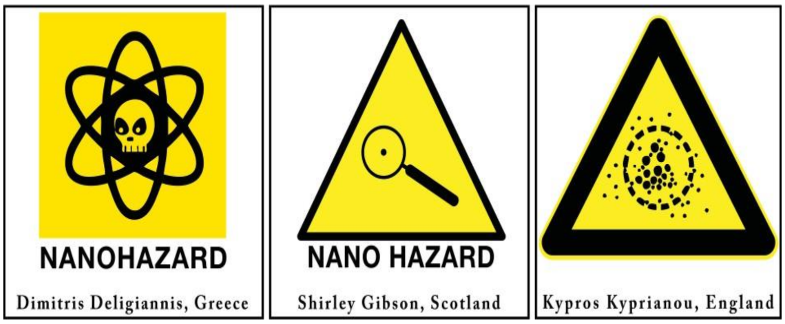

Fig: 1 Nanohazard Symbol, Winners of the Symbol for Nano- Hazard, called by the ETC Group during the Global Social Forum in Nairobi, 2007

As a result of mounting scientific evidence and sustained activism, a number of countries adopted national strategic frameworks in a (mostly failed) effort to balance the management of uncertain risks without compromising innovation and potential benefits. Examples of countries with such frameworks include the U.S., Germany, the Netherlands, and Australia, just to mention a few. There are an increasing number of ongoing research projects under the auspices of these frameworks to characterize and mitigate these risks.

9) Strategies on Nano Science in Asia-Pacific:

In the Asia-Pacific Region, the kinds and scale of national strategies that countries have developed vary widely and are largely dependent on the 'economic position' of the country in question. An increasing number of databases hosting scientific articles, research reports and other forms of data about the health and environmental risks of diverse engineered nanomaterials frequently used in nanoproducts and industrial applications are becoming available. These initiatives aim to,

First, collate data on risks of engineered nanomaterials from diverse scientific reports; and,

Secondly, establish how the accessible data can be applied to understand risks associated with nanotechnology.

To this end, several databases on different types of engineered nanomaterials have been developed by various organizations internationally.

The International Council on Nanotechnology (ICON), an institution at Rice University, in Houston, U.S., researches the risks of engineered nanomaterials and hosts a database on the health, safety, and environmental effects of these materials. From 2000 to 2010, the database registered a sustained increase in published articles in the scientific journals dedicated towards understanding the potential risks of engineered nanomaterials to human health and the environment.

By 2013, there were 4469 peer reviewed and published scientific articles listed in the ICON EHS database in relation to nanomaterial particle type, hazard, or risk exposure group. This accumulation of scientific knowledge no longer permits ignoring the reasonable suspicion that various engineered nanomaterials will pose a variety of toxic effects to human health and the environment. Although the overall picture is highly complex owing to the large diversity of engineered nanomaterials and their distinctive forms, the section below presents a few examples to illustrate the potential risks of engineered nanomaterials

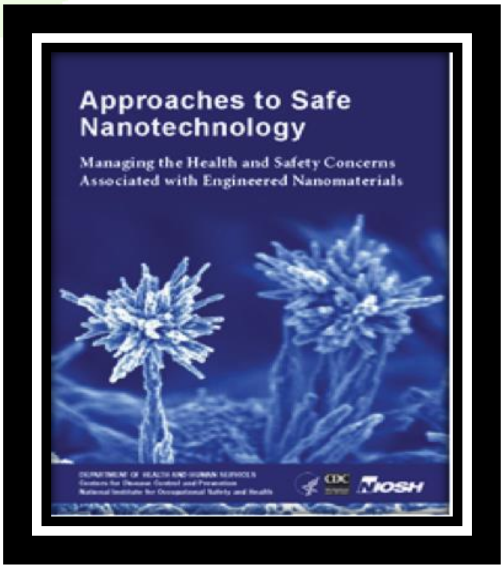

Figure 2: NIOSH (USA)

10) Conclusion:

The development of nanotechnology 21st century in India has been mainly conceived and continued on the premise that this new and emerging technology has huge potential to help the country address societal challenges such as provision of drinking water, healthcare, etc., and simultaneously achieve economic gains through growth in the nanotech-based industrial sector.

There have been various concerted efforts since early 2000s by the government of India to foster and promote nanotechnology.

- The Plan documents and various initiatives taken by various departments/ministries have placed much emphasis on this technology.
- The infrastructure development for basic research and human resource development has been the prime focus in the first phase of such initiatives (2007-2012), which is basically the first phase of Nano Mission.
- In the second phase, which begins with the Twelfth Plan period, i.e. 2012-2017, the focus would be on product development and commercialisation for markets and consumers. In addition to this, there have been efforts to establish a regulatory framework at national level for addressing the risk and safety aspects of nanotechnology.
- The world over, there have been serious efforts taking place in this regard and this is the high time that India too come up with a framework to ensure safety of humans and environment and minimise any unintended consequences out of the use of nanotechnology.
- The multilateral/bilateral cooperation play a major role in promoting cutting-edge basic R&D by providing Indian scientists access to sophisticated equipment/facilities in advanced countries.
- India's early involvement with various international/ inter-governmental organisations, such as International Standards Organisation (ISO), Organisation for Economic Cooperation and Development (OECD), and IRGC, for the development of standards, safe lab practices and risk governance is quite significant.

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