Social and environmental effects of the nanotechnology environmental sciences ess...

INTRODUCTION

1. The nanotechnology & nano science deals with the study, assembling, characterising & manipulating matter on the scale of 100-0. 1 nanometres. The field entails working at molecular level as 1 nanometre (nm) i. e. one millionth of 1 millimetre and this corresponds to about 10 times the size of a hydrogen atom.

2. Quantum physics, material science, supramolecular chemistry, molecular biology and various other fields are being affected by the technology and providing new scope of research and development in many fields.

3. Nanotechnology is still in its formative years and yet to be implied to its full potential for the benefit of mankind. Nano technology allow creation and utilization of materials, devices, and systems on the nanometre-length scale. Thus one obtains products with greatly improved, or totally new, features or the properties and the behaviour. Nano scaling offer the opportunity for structures and devices operating in radically different way with respect to the traditional macro scale structures and devices.

4. As any other emerging technology Nano Technology also has various social & environmental issues attached to it. Scientists, environmentalists and scholars are debating on the social and environmental benefits and concerns related with the technology.

METHODOLOGY

Statement of the Problem

5. Nano technology is the science of utilizing nano particles for various applications. The technology allows building a material, atom by atom, that

can assist in developing the material that is better suited for functioning. The technology is new and most of the developments are in early stages of conceptualisation and production. The technology once in use is likely to have revolutionary environmental and social effect across the globe. Therefore there is a need to critically identify and analyse the social and environmental effects of Nanotechnology.

Hypothesis

6. Nano technology is an emerging technology and application of this technology will have a revolutionary effect on the environmental and social aspects of the world in future.

Justification of the study

7. Nano technology is an emerging technology. As the technology deals with particle at the molecular level, it has the potential of building new material which do not occur naturally. The sheer size of the matter or devices created with the help of this technology has it own environmental and social issues related to it. The technology is new and the availability of technology to selected countries creates various social issues. On one hand the technology has tremendous potential which can benefit the mankind in various fields & on other there are various social and environmental issue attached with the use, effect and control of the technology. The technology has tremendous potential & will have significant impact on the mankind in future, therefore there is a need to examine the revolutionary effect of the technology on the environmental and social aspects of the world in future

Scope

8. The study concentrates on the environmental & social impact of Nano technology in future. It analyses the likelihood of a revolutionary impact of the technology on the environmental and social aspects of the world.

Method of Data Collection

9. The major source of data collection has been through books, periodicals, and Internet. A bibliography of sources is appended.

Organisation of the Dissertation

10. The study has been organised under the following heads: -Chapter I - Introduction & Methodology. Chapter II -Nanotechnology: Concept & Application. Chapter III -Present Status of Development. Chapter IV - Environmental Aspects Related toNanotechnology. Chapter V -Social Aspects Related toNanotechnology. Chapter VI -Likely Social and Environment Effects ofthe Technology in Future. Chapter VII -Recommendations. Chapter VIII - Conclusion.

CHAPTER - II

NANOTECHNOLOGY: CONCEPT AND APPLICATION

Meaning of Nanotechnology

" Nanotechnology" derives its origin from the Greek word for dwarf. It deals with research at the scale of nanometres (nm). It is a group of technologies researching the capability to manipulate or control matter, systems and structures on the atomic or molecular scale. The general goal of nanotechnology research programs is to reduce complex and sophisticated machinery into very small operational units. Nanotechnology involves the

development of techniques to build machines from atoms and molecules. Nanotechnology will let us make most products lighter, stronger, smarter, cheaper, cleaner and more precise. Nano science is the study of molecules and structures with one dimension between 1 and 100 nm. Nanotechnology is the application of these nanostructures into useful materials and devices. When bulk materials are reduced in size to the order of nanometers we enter the atomic and molecular realm. At this size materials no longer exhibit the same properties they did at the micrometer and larger scale. They begin to exhibit new, exciting, often useful properties. Nanotechnology is fundamentally a science dealing with materials and has following characteristics:-Development and Research at atomic or molecular levels, with dimensions ranging between 1 to 100 nanometers. Manufacturing and utilisation of devices, systems and structures which have special properties or functions due of their small size. Molecular or atomic scale control or manipulation of matter.

Nanotechnology definitions

Some of the definitions pertaining to the technology are as under:-Nanotechnology is the miniaturization of technology to the billionth of a meter (the nanometer) to the molecular level. It is the design and manufacturing of intelligent miniature machines, programmed to perform specific tasks. Nanotechnology is the postulated ability to manufacture objects and structures with atomic precision, literally atom by atom. This would mirror the abilities of living cells (which do exactly the same thing, although based on evolution and not design). Nanotechnology is an umbrella term covering a wide range of technologies concerned with structures and

processes on the nanometer scale. A nanometer is one-billionth of a meter (10-9m), and marks a threshold where quantum physical effects increasingly play an important role.

Approaching nano dimension (Top Down vs Bottom Up)

There are two fundamental strategies for used in the field of nanotechnology. Top-down approach. It is the traditional way of producing structures. Starting from microtechnology structures and components are miniaturised. The approach involves achieving nano size by physical methods. The most common top-down approach to fabrication involves lithographic patterning techniques using short-wavelength optical sources. Top down approach allow patterning and building of parts in same place thus there is no requirement of the assembly stage. The example of the same is building of integrated circuits(ICs). It is commonly used in Nanoelectronics and nanoengineering. The various techniques such as electron-beam lithography used in microelectronics are already available for exploitation. Bottom-up approach It is a fundamentally different technique. It uses physical or chemical force to arrange various components. The controlled and directed organisation of molecular building blocks (MBBs) and their subsequent assembly into nanostructure is one fundamental theme of bottom up nanotechnology. This principle allow easy formation of two dimensional structures however forming complex 3 dimensional structures poses its own problem.

Fig 2. 1TOP DOWN AND BOTTOM UP APPROACHES

Nanomaterials and Nanodevices. Nanotechnology can be divided into two discreet classes depending on dealing with " Nanomaterial" or "

Nonodevices". Nanodevices deal with invention of functional system where as Nanomaterial focuses on scientific research and development of particular nano-particles which make up the building block for application. Nanomaterials. Within the domain of nanomaterials important areas are Nanostructured Materials, Nanotubes & Quantum dots. Despite having different scales (macroscopic, micro and nano), they can be grouped together as in order to do some useful work they need to be integrated with other components. Nanodevices. Nanodevices comprises of electromechanical systems scaled down to the nano level. The development of technology on this scale may lead to naval applications, especially for activities that are scale specific. Many areas have been noted, and range from being quite mature to very speculative. Two particular areas that have significant potential from military perspective are. Miniature electromechanical systems, similar to our day to day machines comprising of integrated mechanical and electronic components. They can be divided into:- (aa)Microelectromechanical systems (MEMS).(ab)Nanoelectromechanical systems (NEMS)- similar to MEMS but at nanoscale.(ii)Nanobots. Made of atoms arranged in a specific pattern these are potentially self replicating, programmable devices.

Fig 2. 2COMPONENTS OF NANOBOTS

Application of Nanotechnology

Area of Application Based on Complexity Involved. As nanotechnology is an interdisciplinary endeavour, in designing the systems at nanoscale and analysis of the phenomenon the borders between different scientific

disciplines become vague. Based on the degree of complexity involved the application of the nanotechnology can be subdivided as in table given below.

Table 1- Areas of Application of Nanotechnology

Ser No

Application

Example

(a)

(b)

(c)

(a)Powder of NanoparticlesPaint, Sunscreen(b)Nanotube, NanowiresCarbon Nanotubes(c)Simple Layers of nm scaleMolecular Electronic, Protective Coatings, Solar Power Generation(d)3-Dimensional Layered ArrangementsMagnetic Storage(e)3-Dimensional Random Arrangement3-Dimensional Molecular Memory(f)Linear ChainInformation Carrying Molecule(g)Complex Surface StructureNano-mechanical Devices(h)Fully 3 D, Non self replicatingBio-molecular computer, Nanomachines(j)Fully 3 D, Self replicatingSelf-replicating Nano-robotsOther Areas of Research and Development. Application of the technology has affected various branches of sciences. Researchers world over are being inspired by the technology and are extending the reach of this technology. Some of the applications are discussed as under:-Carbon Nanotubes. Naturally carbon occurs as graphite and as diamond. The difference in arrangement of the atom gives its distinctive form. When carbon atoms are rearranged in a " chicken wire" pattern and further rolled into miniscule tubes (size of only 10 atoms), the

resulting " nanotubes" obtain some astonishing qualities like 100 times the tensile strength of steel with only 1/6 weight, 40 times stronger than graphite fibres, conductivity better than copper. With these properties it can be used in variety of applications.

Nanotechnology and Energy.

Energy conversion and useThe technology can be used to enhance the effectiveness of energy conversion. Some of the example include use in Solar Cells, Fuel Cells and production of energy using microchips. These products once employed will enhance the efficiency of devices and will help in conserving the energy. Solar Energy. Present solar power technology is not economical due to cost of solar cells and photovoltaic modules used to garner electricity from sun’s energy directly. Nanotechnology can help in manufacturing affordable solar cells thus creating a viable alternative of energy production. Nanotechnology and Computer Science. The silicon computers used today have limitations of size and heat generated by various components. Nanotechnology will facilitate manufactures to design & assemble molecular computers proficient in storing terabytes of data in in devices as small as a deck of cards. Apart from that the technology can help to achieve faster data processing and transmission, better optical, optoelectronic & electronic components at a lower cost. NanocomputersNanocomputers will be able to process equivalent applications one billion times faster than present day computers. The applications will include artificial intelligence (AI), which is likely to introduce an all together different approach to the way we look as computer and " smart devices" as we see today. Biomolecular Computer. Present day

computers consisting of wires, chips and plastic will be replaced by computers consisting of DNA molecules and enzymes. Bio molecular computers consisting of biological molecules are capable of performing billion diverse programs concurrently. Some versions of this self-governing computer can undertake operation without human assistance. Nanotechnology in Medical Sciences. Nanotechnology holds immense potential for sophisticated medical diagnostics, biosensors and implantable material or devices. The technology can enable will facilitate instantaneous disease diagnosis, pathogen identification, chromosome replacement, and individual-cell-surgery using molecular machine systems and nanobots. Some of the application in this field are as under:-Nanomedicines. They are ultra minuscule drugs that can help treating life threatening and incapacitating diseases and are gradually being used in clinical practice. Drug Delivery Technologies. Outstanding progress has been made in last 10 years in biomaterials for drug delivery systems. A precise and dynamic medical treatment has been made possible by advancement in pharmaco-kinetics and bio distribution. Nano-device expertise allow attaching the drug molecules on the surface thus allowing greater than ever exchange of drug molecule through sustained release thus resulting in improved efficacy and reduced side effects. Portable Genetic Risk Detection. Modern handheld bio sensing device, based on micro and nanotechnology will allow doctors to caution patients of their genetic risk of budding diseases like cancer well in time. Brain Wiring. A group of researchers from USA and Japanese have demonstrated a procedure where a platinum nano wires 100 times thinner than a human hair will allow doctors to monitor a person’s brain cells through blood vessels as means to guide the wire to specific location in the

human body. The technology can one day allow doctors to scrutinize individual brain cells and perhaps provide innovative treatments for neurological disorders such as Parkinson's. Organs Development. Scientists are effectively using the technology to restore damaged organs. Scientists of South Korea and USA have demonstrated capability of neuron restoration in brain-damaged rats using tiny nanotubes. Scientists of USA have successfully used self assembling nano particles to restore heart functions in rat having heart disease. As can be seen from the above examples, the nanotechnology is influencing various fields. The above examples are by no means cover the complete spectrum which this technology is influencing. Some of the other areas affected by this technology are Defence, Telecom, Optics, Textile, Agriculture, Household, Aerospace etc. A diagram representing the various applications of the nanoparticle is as produced below.

Fig 2. 3APPLICATIONS OF NANOPARTICLE

CHAPTER - III

PRESENT STATUS OF DEVELOPMENT

Nanotechnology: Research and Development

Research and development (R & D)in the field has gone at a moderate pace. Countries like USA, Germany, Japan, Korea and China are leading the world in this aspect. Parallel developments have taken place in the civil as well military application of the same. The US National Science Foundation (NSF) has planned further development in this field and has given it priority amongst top six areas. EU Framework Program for R & D in Europe has taken this as one of the field of development. The field has been the focus of R & D

globally. Many countries have initiated R & D and financial support in the field. Amongst the world leaders in this field focus is directed towards respective capability and requirements. Estimated gross global investment on R&D in 2007 amounted to $13. 5 billion. This includes public and private sector expenditure. In 2007 expenditure by private sector in the field witnessed an increase of 23%, amounting to $6. 6 billion. This expenditure has surpassed the investment by the government for the first time. Apart from military application, the technology has influenced three major industry sectors. Material & Manufacturing. Electronics. Health care & life science.

Ser No

(a)

Industry/ Sector

(b)

Application

(c)

(a)Materials & ManufacturingCoatings and composites for products like automobiles and buildings. Clothing. Improved manufacturing processes. (b)ElectronicsDisplays Devices. Computers. Batteries. Nanobots.(c)Health Care & Life SciencesPharmaceutical Applications. Treatment and Medication. Health & beauty products.

Table 2- Major Areas of Development in Civil Sector.

As per the reports of Woodrow Wilson International Center for Scholars' Project on Emerging Nanotechnologies (2009), majority of 1000 company identified nanotechnology products in the market are being produced by USA

based companies. An analysis of various category of products indicates that the technology is influencing the consumer goods industries in a major way.

Table 3- Percentage Shares of Different Categories of Nanotechnology Products by Country, October 2009

Another estimate by Lux Research indicates that nanotechnology-derived revenues will attain 15% of projected global manufacturing output ($2. 6 trillion) in 2014 as compared to 0. 1% in 2006 ($50 billion). Indian Scenario. India is initiating R & D programme on nanotechnology in various fields. In the recent past institutes like IIT Mumbai, IISc Bangaluru, DRDO & Amity Institute of Nanotechnology have initiated R & D in this field. In the words of India’s former president and eminent scientist Dr APJ Abdul Kalam." The road map for India’s Nano Science and Technology has been evolved based on the Conference cum Workshop conducted at the Rashtrapathi Bhavan on the importance of India entering into the Nano Science and Technology in 2004. On the recommendations of the Conference, the Govt. Of India has approved the programme with the necessary financial outlay and initiated number of R&D activities in Nano science and technology. This programme had commenced in multiple laboratories and institutions in Research and Development of Nano Science, Technology leading to product development and marketing globally."" For us to succeed in manufacturing of nano products and their deployment we need to tackle the issues of science and technology, product development and societal aspects in an integrated way. Judging by the past experience of the country in driving technology missions like in Aerospace, Agriculture, Atomic energy and IT, I am confident that, if

we take in a mission mode with a clear-cut vision, the country will reap the benefits of nano-science and technology."

CHAPTER - IV

ENVIRONMENTAL ASPECTS RELATED TO NANOTECHNOLOGY

Nanotechnology deals with nano particles. Nano particles have the potential to provide environmental benefits both in the process by which products are produced or by the type and quality of products produced. At the same time smaller size of particle has its own drawbacks. The products of the technology are so small that they can pass through skin or blood barrier with ease. A large number of the nano particle produced can be very reactive in nature. A number of tests have been conducted so as to ascertain the behaviour of these particles in nature, but as of now these tests are restricted to the environment of laboratories. In actual conditions a number of factors and agents ascertain the behaviour of these particles and the complex interactions in such condition is difficult to ascertain.

Environmental Benefits of Nanotechnology

The technology provides plethora of benefits to include reducing pollution, cleaner and more efficient industrial processes, better health care and energy conservation etc. According to the Environmental Protection Agency (EPA): " nanoscale cerium oxide has been developed to decrease diesel engine emissions; iron nanoparticles can remove contaminants from soil and ground water; and nano-sized sensors hold promise for improved detection and tracking of contaminants". Some of the benefits are being discussed in subsequent paragraphs. Better Monitoring. The technology allows production

of devices that can facilitate detection of harmful agents with better efficiency than the existing devices. These devices have the capability to monitor a wider range of pollutants and toxic agents on site and in near real time. Today’s most sensitive chemical detectors are unwieldy, powered by batteries and weighing many pounds. These sensors are more convenient and even wearable.

Fig 4. 1Monitoring Air Pollution Hotspots

(Thin film of nanocrystaline metal oxide in solid state sensors

allow air quality monitoring)

Fig 4. 2Detecting Water Contamination

(Simultaneous detection of more than 25 contaminants byexploiting biochemical sensors)Remediating Pollution. The technology has the capability of reducing or mitigating the pollution at the very source. Research has shown the potential of nano structured catalyst (based on nanoparticles) in reduction of industrial and vehicular pollution. These catalysts convert carbon monoxide (CO) to lesser harmful Carbon Di-Oxide (CO2). Some of the other examples of the same are as under:-Synthetic zeolites Filled with identical nanometer size material for production of lead free gasoline. Nanotechnology used in catalytic converters to reduce carbon emission by automotives. Nanoparticles used in new refrigerants to replace chloroflurocarbon (CFCs). Improved Energy Production and Conservation. Present energy crisis can be mitigated by two ways i. e. by concentrating on renewable sources of energy and by increasing the overall efficiency devices. Sun provides abundance of energy and an efficient solar energy

production mechanism can offset the burden borne by traditional means of energy production. Nanotechnology can also provide better ways of storage and consumption of energy, thus providing a better alternative. Some of the examples are stated as under:-Printing Solar Cells can be used as an alternative for traditional semiconductor crystals which absorb only 20 % of solar energy. Printing solar cells can be printed like a news paper and be effectively used for production of solar energy. Fig 4. 3Printing Solar CellsElectrodes containing Lithium Cobalt Oxide provide better storage capability in rechargeable batteries. These batteries have better charge and discharge rate and are said to be more efficient than the present batteries. Fig 4. 4 Electron Microscope Image of Nanostructured Electrode Used in Advance Lithium Ion BatteriesHydrogen fuel cell used by the automotive industry uses hydrogen as fuel and water as by product. Present capability to store hydrogen by using metal hydrides is complex and potentially hazardous. Nanotechnology can provide solutions for better means of diffusion of hydrogen thus providing a better and environmentally efficient mode of transportation.

Nano Pollution

Development of a technology without understanding the long term effect of the same on environment and mankind can be hazardous. Though nanotechnology deals with small particle but the effect of these particles on the environment have not been quantified or analysed in totality as yet. Three major issues that need careful analysis are as under:-How will the nanoparticle interact and transform in the environment? What will be the effect of these particles on the Ecosystem? What will be the effect of these

particles on the various life forms and the organisms? Due to miniscule size and possession of totally different physical and chemical characteristics than the parent element or compound these particles have the capability to be transported easily, penetrate skin barrier and alter physical/ chemical property of naturally existing material. Each environmental medium also dictate the effect of these particle on the environment. Some of the issues are being discussed in subsequent paragraphs. Air. Nano products being lightweight and small size have the capability to be easily transported by the medium of air. This allows uncontrolled transportation of the same over countries and continents. This implies that the effect of these particles are not localised and will have global effect. At present no substantive study has been carried out to mitigate this issue. Water. At present there is a lack of data which indicate the biodegradability, biotransformation and bioavailability of nano particles in water. Naturally occurring suspended particles have a natural tendency to combine and precipitate out of water. Lack of adequate data on the capability of nano particle to precipitate out of water does not allow to accurately predict the behaviour of these particles in the medium. The issue is further exasperated when organic life and ecosystem in water is to be taken into consideration. Other issue related with water is the basic characteristics of naturally occurring water. This implies that due to differences in naturally occurring water due to characteristics like solubility, salinity, level of other minerals like phosphate and chlorine etc, thus make the analysis more difficult. Soil. Effect of the nano particle on soil is largely unknown. Nano particles can either chemically combines with soil or might remain unabsorbed. Chemical combination has the potential to alter the chemical and physical property of the soil altogether and unabsorbed

nano particle have the capability to either dwell on the surface or position themselves in the gaps of the particle thus effecting the soil. These effects may alter the characteristics of the soil thus affecting cultivation and altering the food cycle. Health Risks and Toxin Effects. Presently the study and analysis of health risks and toxin effect on eco system and organism has been limited. " The US government estimates that 2 million American are already exposed to nano-scale materials regularly". Presently it is impossible to say the ecotoxin effect of nanotechnology in actual conditions. Details and the varied effect of some of the tests carried out are as under:-Fluorescent Latex nano particles suspended in water affected all the organs, even eggs of Medaka Fish (Oryzias Latipes). The extent of the effect was dependent on factors like the size of nano particles and the salinity of water. Product like Titanium Di Oxide (TiO2) which is used in cosmetic product like sunscreen has virtually no effect on healthy human skin, but when it is released in water adversely affects Algae and water flees. Nanotechnology has dual effect on environment. At one hand the technology is benefiting environment on the other uncontrolled use of the technology can lead to potential environmental hazards. Correct balancing of the requirements benefits and risk assessment will allow mankind to harness true potential of the technology without further degrading the already fragile eco system.

CHAPTER - V

SOCIAL ASPECTS RELATED TO NANOTECHNOLOGY

The nano technology is flourishing and it can contribute to mankind in many ways. Every technology brings about societal and environmental impact. The

environmental aspects have been highlighted in previous chapter. The chapter deals with the social and ethical issues related to the technology.

Ethical Role of Government

Government of any nation plays a very important role in supporting the research which raises awareness and promote the issue of social and ethical aspects related to a technology. As the length of time between discovery and commercialisation shrinks, oversight as a methodology for checks and balances becomes less useful. Some of the examples that are of concern with this technology are " Human Genome Project" and " Genetically Modified Crops". Importance of Government in Development of Any Technology. The aim of development of any technology is to contribute to human flourishing in a socially just and environmentally sustainable way. The role of government in development of technology will include:-Define what is meant by :-Justice. Human Flourishing. Environmentally Sustainable way. Identify the various opportunities offered by the technology and ascertain the hurdles in achieving the same. Propose the measures for accessing the future technology. Build the capability and method to help various agencies to take ethical decisions for the benefit of mankind. Define the limits on how the goals that needs to be achieved by the technology should be achieved.

Nanotechnology and Social and Ethical Issues

Relationship of Society and Technology. Technology is a social phenomenon. Technology is based on the requirements of the society and is encouraged by same. It is the social requirements that either allow dissemination and implementation of the technology or prohibit and reject the same. The technology on the other hand has the capability to transform the society.

Some of examples of technology that transformed the society are Electricity, Nuclear Technology, Information Technology (IT) and Mobile technology etc. The user of technology also affects the way the technology influences the society. Use of nuclear technology for WMD and peaceful use and use of IT by militants are some of the example available. Thus it can be stated that the technology and society are interrelated and inseparable. The ethical issues related with the technology can be addressed under following heads:- Social Context Issues. This issue arises because of interplay of social and/ or institutional issue related with technology. It can be stated that the nanotechnology itself will not bring about the contentious issues however the differences in the society and issues like restricted access to the technology, insufficient commercial accountability, externalization of contamination and health costs, asymmetrical exposure to environmental burdens, will bring about a variety of social context issues associated with the nano technology. Moral Issues. The moral issues related with the technology deals with the issues which are considered immoral by a certain segment of the society. Some of the examples of such issues related with nanotechnology are genetic modification of living organisms and chemical and biological weapons development etc. Technoculture Issues. It arises from problematic aspects of the nano technology which affects social system. Example of same is overdependence on nanotechnology to correct/ negate the problem causing effect rather than addressing the core issue related with technology which is causing the problem/ ill effect. Addressing various environmental issues by nanotechnology can be seen as a step in this direction. Form of Life Issues. The issue arises from the overall impact of nano technology on humans thus effecting social standards, social practices and change in

various social institutional norms. For example if the life expectancy of humans is increased by better medical and genetic modifications, the impact it will happen on the age of marriage and requirement of care of the elderly. Transformational Issues. The issue is based on the effect of nano technology on aspects related to the very kind of human beings we are today and the changes that the nano technology can bring on the future generations as human beings. The example can be drawn from the development in Artificial Intelligence (AI) and genetic modifications so as to create more perfect genetically modified human beings. Such changes will alter the way we will interact with the environment and each other in the future thus bringing about social and ethical issues. Social Issues Related With Nanotechnology. Nanotechnology is an enabling technology with general usages in the society. This implies that the technology is affecting or going to affect the society in future. The issues are more pronounced due to differences in social structure within a country as well as globally and the way the people are exposed to or alienated from the technology. Some of the issues are discussed in the subsequent paragraphs. Biased Access to Technology. Nanotechnology is an high end technology. The initial cost of the R & D is high. There are indicators that the technological expertise required and the cost of technological development will restrict the access of the technology to the selected few within a country and even within various countries. The uneven distribution and access to technology can be evaluated by analysing the number of patents in single aspect like healthcare undertaken by various countries.

Table 4 Distribution of Health-related nanotechnology patent activity (1975-2004).

Inadequate Privacy/ Security Concerns. The small scale of devices and ability to intrude in private lives can lead to privacy and security concerns. With the development of nanobots and nanodevices the technology allows a medium to intrude into the private life of individuals and organisations. It is further related to security issues where private information can be used to exploit vulnerabilities of an individual, group or a nation. Unintended and Second-order Consequences. Once a technology has been commercialised and the technical knowhow is available, subsequent development of the same is also available to its users as well. The flow and impact of technological development often depends on the expansion of corresponding technologies and of the user. This implies that the new technologies can influence society in ways other than the way it was designed to by its original initiator. Religious Acceptance. Religion plays an important role in deciding social acceptance. In the past at one hand there has been a trend of religious liberalisation on the other religiously fanatic behaviour have been seen in some part of the world. Examples of same have been seen during implementation of simple things like birth control, immunisation of children and abortion laws. Though globalisation, economic development and quest for scientific development will take precedence however actual implementation of the technological benefits of nanotechnology will be weighted by religious heads in respective country. The other aspect is the definition of moral and ethical values by religion. Genome experiments, AI etc will be weighed differently by different religions. Thus global implementation and acceptance of same will be a complex issue.

CHAPTER -VI

LIKELY SOCIAL AND ENVIRONMENTAL EFFECTS OF

THE TECHNOLOGY IN FUTURE

Social and Environmental Effects of Nanotechnology

Social and Environmental Benefits of Nanotechnology. The likely benefits of nanotechnology can be summarised under following heads:-Ecological Aspects. The surface area of the nano particles is more in comparison to their volume. This allows production of:-New and better catalysts. Thus reducing the chances of production of unwanted by products. Films or coating which have improved capability to reflect thermal energy. Superior Insulators. Stronger and wear resistant fabric. Self cleaning glasses. Special coating on walls which have better cleaning property. Magnetic nano fluids which can replace hydraulic oil in certain machines. Membranes which allow cheap alternative for water purification. Better and improved renewable energy production systems. Tools for efficient energy management.

Dematerialization.

Nano crystals having better size distribution can be combined together to form miniscule parts which have higher strength and superior mechanical and thermal resistance. Thus producing efficient machines. Production of such nano material can replace the requirement of scarce materials which are required for production of material having similar qualities. Thus saving scarce natural resource. Lesser energy consumption in fabrication of such substances by using new processing technique which involve lesser temperature during manufacturing stage. Clean Technology. Nanotechnology

provides a better alternative towards cleaner technology over the conventional methods. Some of the examples are stated as under :- Improving the effectiveness and accuracy of chemical reactions in various processes by designing nano catalysts which are produced using precision technology. Production of stronger and lighter material thus saving energy and raw material. Improving the capability and efficiency of product based on renewable energy like solar energy. Improved energy production and storage capability. Production of better and improved photovoltaic cells as compared to conventional ones. Health. Nanotechnology has contributed considerably towards healthcare and medicinal science. Some of the benefits and applications of same are mentioned as under :-More efficient medicines with minimal side effects because of better understanding and precise production of products like insulin or hormones. Improved drug delivery system coupled with medicines empowered by nano technology, thus improving the treatment techniques. Use of magnetic particles in the drug delivery which allow external control on the medicine by providing better target information, thus providing accurate drug delivery mechanism. Hyperthermic therapy using magnetic particle as an alternative for traditional cancer therapy. Preventive medicinal capability using combination of bio sensors and drug delivery systems. Better and improved warning systems for presence of toxins in the environment. Employment of nano machines in human body for detection and destruction of sickening agents like cancer or fat cells. Possibility of employment of similar machines for molecular repair of damaged or diseased cells. Providing better analytical property which allows detailed study of various steps during the production

and development of medicines. Better diagnostic and medicinal capability thus improving health care and life expectancy of humans.

Process Security.

Nanotechnology allow production at nano scale thus allow production of various scales which provide better calibrated and precise standards for(aa)Analysis of material.(ab)Quality control purposes.(ac)Treatment of various materials. Storage disks which have better magnetic storage capacity. Electronic systems which have multilayered capability. Precision technology allows better positioning of sensors with drastically improved sensing and controlling property especially in automotive industry. Electronic and Communication Technology. The technology has the potential to enhance the potential of electronic and communication technology. The nanotechnology based electronic and communication products allow far superior processing and storage capability. Some of the benefits are are as under : -Development of nano sized electronic data storage and processing system. Nanotechnology based building blocks which can be used for production of digital electronic units. Mechanical arrangements which are molecular in nature and demonstrate the capability of performing various logical actions as required in various electronic circuits. Social and Environmental Risks Associated with Nanotechnology. The technology has the potential to provide tremendous benefits to mankind however certain risks associated with the technology are due to aspects like nano size, self replication, interaction with natural environment, genetic modification and degradability etc. Some of the aspects are mentioned as under :-Genetic Modifications. Part of the nanotechnology based products include genetic

material and have the capability to genetically modify or alter organisms. Though the property has been envisaged to be used for benefit of mankind, it can have following risks :-" Unintended and Second-order Consequences" may lead to uncontrolled modifications thus drastically affecting ecological balance. Risks of failure and further consequences associated with drug delivery systems which are based on some kind of sensing and computing system. Ethical and moral issues related with genetic modifications and creation of a new life form which do not occur naturally." Form of Life Issues" correlated with genetic modification and AI. Nano scale of artifacts. Nano scale particles and its usages pose various concerns. Some of the concerns are being highlighted as under :-Security concerns envisaged with likelihood of planting devices which have communicating and computing capability in human body without the knowledge of individual. Ethical risks and issues related with nano-sized active implants on hosts specially humans. Security and safety concerns of individual, group or organizations, since it will be very difficult to detect the presence of such articles. Uncontrolled release of nano waste, ease in spread and likely environmental effect. As a paradoxical to above nano particles allow the capability of controlled release of biological and nerve agents in warfare. Self Replicating and Self Assembling Capability. Nanotechnology allows self replicating and self assembling capability. The various risks associated with the same are as under :-Effect on the manufacturing industry where there will be requirement of small number of highly skilled people for performing such tasks. This will have social implications. Self replication and self assembling capability will generate newer active and or waste products. Newer processes and methodology will be required for control and processing of active or waste products. Failing

which will lead to environmental implications. Ethical issues related with encouraging the development of unnatural self replicating devices/ organisms. Social issues related with self replicating devices which are associated with likelihood of creation of non carbon based organisms in future. Interaction with Environment. Interaction of nano particles with environment poses various risks right from contamination to degradation. Some aspects are mentioned as under:-Nano particle are difficult to recycle as compared to conventional materials. Nano composites produced as a result of the technology will pose environmental problems. Though the lab tests have been carried out however exact way these particles will reciprocate in natural conditions and its effect on the same is yet to be ascertained. It can be seen from the above examples that nanotechnology will definitely affect mankind. It is affecting various other prevalent technologies. Once exploited it will definitely drastically change the way we perceive various technological aspects around us. The effects of same are now visible to us in various fields. Once fully exploited the technology has the potential to affect us both socially and environmentally. The technology offers benefits as well as risks. The social and environmental dangers of the technology are evident. Environmentally it has the potential to cause irreversible damages and destroy the already fragile eco system. The societal and ethical issues related with the technology are raising newer questions and there is a definite requirement to answer them.

Opportunity and Challenges

Opportunities. Nanotechnology provides various opportunities to mankind Being an enabling technology it is revolutionising the associated technology

as well. Most of the societal and ethical issues associated with emerging nanotechnologies are determinate, pressing, different, noteworthy and actionable. It is important to balance the positive and negative aspect of a technology and take proactive actions so that the benefits of the technology can be reaped by the mankind without adversely affecting the social and environmental aspects related to it. The potential environmental and social benefits related with the technology can be summarised as under:-Helping environment by reducing energy consumption, greenhouse emission and thus reducing pollution. Design and implement better, cleaner and more efficient industrial processes. Remediating environmental damage. Improve healthcare by providing improved and better options of curing, managing and preventing diseases. Provide new material that are capable of protection against external force, self repair capability, provide better and improved protection and aiding soldiers and workers working in hazardous conditions. Governments of various countries will pay a major contribution in determining the ethical, social and environmental criterion for application or rejection of the technology. Adequate balance has to be sought between commercial, developmental requirements and the societal and environmental risks associated with the technology. USA launched National Nanotechnology Initiative (NNI) in 2000 with eight agencies. NNI as of today comprises of 26 Federal Agencies with a range of research and regulatory roles and responsibilities. Apart from various issues related with development of technology Social, Ethical and Environmental concerns are being looked after this agency. The NNI accelerate the innovation, expansion and exploitation of nanotechnology for the mankind. It is involved in a number of programs where various agencies are working together to achieve

the goal of NNI. The vision of NNI include four primary goals. To advance world-class nanotechnology research and development; To foster the transfer of new technologies into products for commercial and public benefit; To develop and sustain educational resources, a skilled workforce and the supporting infrastructure and tools to advance nanotechnology; To support the responsible development of nanotechnology. In the Indian context various ministries like Department of Science and Technology (DST), Defense Research and Development Organisation (DRDO), Council of Scientific and Industrial Research (CSIR) and Department of Biotechnology have been supporting research projects and some facilities in facilities in Nanoscience and Technology. DST has launched a national programme titled ‘ Nano Science and Technology Initiative’ (NSTI) in October 2001. Such programmes have concentrated on R & D, improving infrastructure facilities, create centre of excellence and generate trained manpower. IIT Bombay is one of the premier educational and research institutions in the country. Centre for Research in Nanotechnology & Science (CRNTS) has recently been formed in the institution with the grant of Department of Science & Technology (DST), Government of India. IIT Bombay boasts of having over 45 academicians and scientists from various departments and schools who are working collectively on the subject of Nanotechnology. IIT Bombay has also been selected as one of the two institutions in the country for setting up a 'Centre of Excellence in Nanoelectronics' by the Ministry of Communications & Information Technology (MCIT), Govt of India. The main objectives of CRNTS can be summarised as under:-Strengthen the Nanotechnology infrastructure and research activities at IIT Bombay with state of the art facilities for Nanotechnology research. Identify potential industry partners for

commercialization of Nanotechnology research. Facilitate construction of a 80, 000 sq. ft Nanotechnology building with all the required amenities to house the Nanotechnology centre facilities. Create technically sophisticated manpower for Nanotechnology research, engineering and manufacturing by:- Enabling a large number of doctoral students to conduct their research work in the Nanotechnology centre. Creating a suite of courses for graduate level teaching of nanotechnology, and admitting masters and doctoral students to this programme one that would have a strong experimental research component. Setting up an inter-university cooperative programme in which graduate students and leading researchers from other universities can come and take courses & do their research projects in the facility created. Running summer courses in nanotechnology for university teachers and industry professionals. Network with other agencies, institutions, national labs and industry working in the area of nanotechnology. Challenges. It can be seen from the above examples that though various countries have started R & D and have initiated the commercial use of nanotechnology. In countries like USA launching NNI indicates that the initiative and thought process exist however the exact model required for implementation seems inexistent. In India the Governments thought process and the objective of a premier institution like IIT Bombay indicates that, though enough stress is being laid on R & D there is limited or total lack of sensitisation towards the social and environmental aspects related with nanotechnology. Lessons can be drawn from past experience (previous emerging technology) and its effect on mankind. Expertise in respective fields which are being affected by this technology can correctly visualise the likely effect. Prevalent technology has definitely brought technological advancement however in the race of

development we have overlooked the social and environmental aspects. The results of same are clearly visible in our day to day life. A dedicated effort of scientists, research scholars, legal experts and governments is required to utilise the true potential of this technology. It is important to study this technology not only as a science and engineering subject but as a social science and humanities perspective as well.

CHAPTER- VII

RECOMMENDATIONS

Issues Meriting Attention. During the course of dissertation following aspects have emerged:-Nanotechnology is an enabling technology and it is affecting various associated technologies. The technology has the potential to bring revolutionary changes in the society and environment in future. The technology has risks as well as benefits associated with it. Government plays an important role in propagating, restricting or negating various aspects of a technology and it has a direct bearing on the use and exploitation of the technology. The outcome of the technology (both positive and negative) are not equally disseminated within a society in a country and within developed, developing and under developed country. Though R & D, infrastructure development, training of a competent workforce and commercialization of nanotechnology is underway, adequate R&D on social and environmental aspects related with nanotechnology are not been carried out. Adequate scientific data is not available on the societal implication and environmental dangers associated with the technology.

Recommendations.

In view of the complex social and environmental aspects related with nanotechnology, role of various governments and industries associated with this technology, the recommendations are as given in succeeding paragraphs. Keeping the benefits of the technology in mind the R&D to continue. Organisations and initiatives like NNI to be formed in all countries to monitor the developments in this field and take initiatives to negate the ill effects of the same. Initiative should be taken to incorporate experts from humanities and social science subjects in the R&D and its implication on society. There is a need to encourage, nurture and train a new generation of scientists and research workers in the field of nanoscience at each level based on the specific set of courses and curriculum designed to:-Include social, environmental, moral and ethical implications and likely effect of nanotechnology. Analyse and exploit nanotechnology and its effect of its concept on subject like mathematics, science, engineering and technological education. Create competent and well trained social and environmental scientists who are empowered to contribute towards the impact of the technology towards the same. Provide adequate opportunities to students and research scholars so that they are capable to exploit the interdisciplinary capability of the nanotechnology in order to exploit the maximum benefits of the technology and negate its ill effect. Generate capability to establish rewarding partnerships between industry and educational establishment to provide adequate experience to the students of the nanotechnology with fabrication, manipulation and production techniques which are socially and environmentally sustainable. There is a need to address various social issues like genetic modification, invasion of privacy etc through a global discussion.

Environmental aspects related with the technology needs special attention. There is a requirement to undertake an initiative to collect scientific data on the likelihood of short term and long term effects of nanoparticle and nanodevices on the eco system. Global endeavor should be made so that like Nuclear Technology, nanotechnology should not be restricted to selected country. On the other hand adequate care would be required to be taken so that the technology is not being misused by certain groups/ non state actors for their own misadventure. There will be a requirement of establishing and strengthening legal system which should be able to address various risks and ill effects of the nanotechnology under its ambit. Providing higher priority to research and study on social and environmental aspects related with nanotechnology. Encourage various research centers to incorporate social science research on social implications in the nanotechnology. Plan for creating nodal research centre on the various social and environmental aspects related to the technology at national and global level. Build openness, revelation, public awareness and participation into the progression of developing, R & D and future plans in the nanotechnology program. Various governments especially world leaders on the subject should be compelled to establish a system to inform, educate, and engage the public on the subject of likely impacts of nanotechnology. The mechanism thus created should be capable of receiving continuous feedback from the various agencies like community involved in R&D and development of technology , industries involved in producing such products, social scientists and public with the aim to :-Provide timely and continuous means to monitor and exploit the potential societal opportunities and challenges. Providing timely input to mitigate potential hazards to concerned

organisations. Create and nurture institutional infrastructure with adequate knowledge base and technical capability to undertake interdisciplinary research which should integrate a systematic approach to incorporate R &D, social and environmental impacts, life cycle analysis and real time monitoring and evaluate scientific, economic, social and environmental impacts in different timelines to include:-Short-term (5 to 7year). Medium-term (7 to 20 year). Long-term (over 20 year). Encourage government sponsored as well as independent professional societies which are capable of developing various forums which in turn monitor and encourage educational activities and debates to inform, educate, and involve professionals in nanoscience and nanotechnology. The recommendations given above seem very simplistic but implementing them will require a mature global effort. There will always be differences of opinion based on economic requirements, need of development, scientific quest, religious, moral and ethical issues and global dominance. Nanotechnology is providing tremendous opportunities it depends on us so as to how we reap the benefits and negate the ill effects?

CHAPTER-VIII

CONCLUSION

With advent of nanotechnology mankind has progressed towards the way nature functions. Now man has been able to design and alter matter up to molecular level. Nature’s way of functioning is more complex and efficient. Natural products or phenomenon are in equilibrium with each other and are mutually sustaining. Probably one day nanotechnology will allow as to replicate the nature, at least partially. Man, society and technology are interlinked. The existence of one is dependent on other. They do influence

each other directly or in directly. The actions of man and products of technology influence environment. In the past adequate examples are available where all technology has influence society and environment. It is important to understand the delicate balance between environment, society and the technology. The greatest benefit of nanotechnology is the ability to influence and convergence of various technologies. At present the technology is at its early stage but is effects can be seen in our daily life. With the present trends in R&D, the technology is on the threshold of major expansion. As the technology can influence various other technologies, commercially it provides abundance of opportunity. The usage of the technology can already be seen in various applications like Refrigeration, sun screen lotions, cloth, medicine etc. It is a major incentive for various countries and industries to propagate this technology. At the same time this factor will play a major role in restricting the technology within a close group and lowering the safety standards for reduced production cost and in turn better revenue. Social, moral and ethical issues related with the technology require a special mention. The technology has the potential for experiments like genetic modifications, AI, production of lethal biological and chemical weapons. Even issues like invasion of privacy, societal changes due to increased life expectancy etc require special attention. Though the technology is providing adequate solutions to various environmental problems however the environmental issues raised by the technology itself require a dedicated and sincere analysis. Nanotechnology has the potential to transform science, technology and society. The transformation has started and within 10 to 20 years, a considerable proportion of industrial practices and production, healthcare concept and methodology and environmental

management issues and concerns will be effected by the technology. Industrialisation, healthcare combined with economic development, personal opportunities and concerns will influence the social, ethical and environmental aspects. In order to exploit the full advantage of the new technology, the entire scientific and technology community, social institutions, general public and governments must be engaged in a combined effort to correctly foresee the future, set broad parameters and guidelines for future development. The technology will definitely have revolutionary effects on the society and environment. Notwithstanding the benefits, the technology will have certain negative impacts on the environment and society. It will be prudent to visualize the negative impacts in totality so that the benefits of the technology can be enjoyed by the man kind without the fear of envisaged social and environmental catastrophe.