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Mohd. Zahid Rizvi, Syed Husain Asghar Kazmi,
Syed Nazeer Haider Zaidi and Sabiha Kazmi

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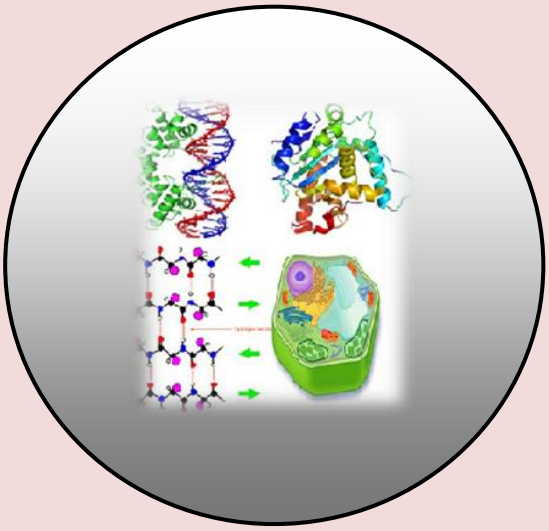

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Dr. M. Zahid Rizvi
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# Role of Nanotechnology in Mitigating Climate Change

**Mohd. Zahid Rizvi, Syed Husain Asghar Kazmi**
**Syed Nazeer Haider Zaidi and Sabiha Kazmi**
**Department of Botany, Shia Post Graduate College, Sitapur Road,**
**Lucknow-226020, Uttar Pradesh, India**

## ABSTRACT

***Alteration in climate is important global issue which is resulted by consumption of fossil fuels and human activities such as overuse of natural resources, agriculture, cutting of forests and environmental pollution. Climate change can cause enhancement in ocean temperature, elevated sea levels, heightened weather phenomenon and endangering species. Climate change negatively affects sustainable development. Nanotechnology, a modern interdisclipnary branch of science, is important in mitigate climate change. Technologies like hydrogen-dependent economy, smart portable batteries with high power storage capacity and solar power based energy can be made more efficient by employing various nanomaterials which may add towards efficient energy use and greenhouse gas reduction thus reducing global warming. The present review paper takes into account the effects of climate change and positive effects and future potential of nanotechnology in mitigating climate change.***

***Key words: Climate change, greenhouse gases, hydrogen economy, nanotechnology, solar power.***

## INTRODUCTION

Due to industrial activities, there is enhancement in greenhouse gas (GHG) levels and human activities are largely responsible for this phenomenon. They have added towards climate change through emission of GHGs, altered land use causing elevated global temperature (Karl and Trenberth, 2003). Enhancement in global temperature can cause elevation in sea levels and instances of storm, drought, flooding and melting of glaciers (Mittler and Blumwald, 2010, IPCC, 2014). Therefore reducing green house gases can be an important step towards mitigation of adverse effects of climate change. Climate change is global phenomenon.

Countries employ various parameters and methods to assess impacts of alterations in climate, including those of Intergovernmental Panel on Climate Change (IPCC, 2007). Positively managing environmental pollution and energy usage can have great impact on alleviation of damage exerted by climate change. Nanotechnology is important in mitigation of climate change by helping in development of efficient energy generation, its storage and use.

## CLIMATE CHANGE

The adverse impact of climate change can be observed globally. The unusual changes in weather patterns caused chiefly by enhancement in greenhouse gases ($CO_2$, $CH_4$ and nitrogen dioxide); (IPCC, 2014), can be termed as climate change. The main contributing factors for enhancement in green house gases are fossil fuels, emitted by various sources like industries, automobiles, domestic usage etc (Le et al., 2013). The adverse effects of climate change are everywhere including incremental increase in average global temperature, drought, loss of biodiversity, enhancement in sea levels, mainly caused by melting of glaciers, alterations in physical parameters of oceans like elevated temperature and acidity, reduction in freshwater resources and erratic weather patterns. Climate change indirectly exerts its effects at socio-economic level also (Dawson et al., 2011, Gasper et al., 2011). The first step for mitigation of climate change is proper assessment of its impact on various factors like global temperature, precipitation, various weather phenomenons like storms, biodiversity (flora and fauna), agriculture and human health.

## CLIMATE CHANGE AND NANOTECHNOLOGY

### What is Nanotechnology?

The term “nano” has emanated from Greek language meaning small. The dimensions covered under nano level are in the range of 1 to 100 nanometers (nms); (Ghosal and Thomas, 2018). Due to such small dimensions, nanomaterials are endowed with such physical and chemical properties that are otherwise not seen in normal sized particles having dimensions larger than naomaterials range [(TERI Briefing Paper, TERI 2010, Rajput, 2017]. Due to unusual properties and very small dimensions, nanoparicles (NPs) can be employed in various areas including nanoengineering, nanomedicine, nanobiotechnology, agriculture and environment (including climate change). Nanotechnology has potential to become most significant technology in mitigating climate change in future (Rajput, 2017).

As per reports of BRICS (Brazil, Russia, India, China and South Africa) countries are significant contributors towards GHGs emission (Azevedo, et al., 2018). Nanotechnology may be play pivotal role in mitigating adverse impact of GHGs emission. But lack of funds and an effective strategy and its implementation are hindering these efforts to alleviate adverse effects of global warming and other catastrophic environmental changes, although the progress has been made in this direction in India. India has realized potential of nanotechnology in various disciplines. Government of India has started many pioneering schemes on research and development in nanotechnology including Mission in NanoScience and Technology by Department of Science and Technologyb (DST) for developing the required infrastructure and promoting nanotechnology, marketing of nanoproducts and initiating public awareness about nanoproducts usage (Shefali et al., 2016, Rajput, 2017).

Funding for nanotechnology should be co-ordinated and should be done keeping in mind the long-term development of nanotechnology. Various Government agencies and Research and Development Organizations should devise and implement a multidimensional strategy on nanotechnology to attain significant, long term, high impact outcome so that India can leap forward in nanotechnology.

**Nanotechnology in Mitigating Climate Change**

Nanotechnology can contribute towards efforts to mitigate climate change by adopting various technologies like solar and hydrogen-based power technologies and by developing advance types of superefficient batteries (Esteban et al., 2008, Rani and Sridevi, 2017).

**Impact of Nanotechnology in Energy Storage**

Nanotechnology is important in developing highly efficient rechargeable batteries with high energy storage capacity, potential with charging in lesser time, smaller size and longer life. Examples of such types of batteries are nickel-metal hydride and advanced lithium-ion batteries, thus imparting longer usage time for longer journies. Some other innovations like coating of NPs on electrodes surface can impart higher surface area and more current flow. NPs can help in creating a barrier between liquid and solid electrodes in a battery thus increasing shelf life of battery. Some efficient small thin-film batteries, are also being considered for usage (www.nanowerk.com, https://www.understanding nano.com/).

**Impact of Nanotechnology on Solar Energy-Based Power Generation**

Nanotechnology has wide applications in solar energy-based technologies. Development and usage of silicon NP based systems working like photosynthetic systems, use of non-silicon material to develop thin-film technology, molecular organic solar cells and usage of nanotubes in conducting polymer cells and techniques like quantum dots and nanowires can help in increasing photovoltaic cell efficiency. Use of 3-D graphene in dye-sensitized solar cells can help in enhancing transformation of sunlight to electricity (Esteban et al., 2008).

**Role of Nanotechnology in Hydrogen Power-Based Technologies**

Development of efficient hydrogen-based fuel cells, photocatalytic manufacturing of hydrogen from water and usage of novel nanomaterials for hydrogen storage can cause development of hydrogen based clean, environment friendly fuel system. Employing carbon nanotubes for help in using hydrogen in fuel cell, development of magnesium NP based composite material for efficient storage and release of hydrogen, development of enzyme system catalyzing hydrogen generation and fuel cell activities, using graphene for safely storing hydrogen, are some of the techniques that can promote usage of hydrogen as fuel in future and can contribute in mitigating negative effects of climate change (https://www.understanding nano.com/, Fan et al., 1999, DE Jong and Geus, 2000, Khanna et al., 2008).

## CONCLUSIONS

The research and development in nanotechnology for development of nanotechnology-based products and processes like hydrogen and solar based energy systems and small sized, high storage capacity batteries can boost the efforts of mitigating negative impact of climate change by causing low usage of raw materials, developing efficient energy generation, decreasing greenhouse gases emission and thus promoting preservation of biodiversity and sustainable development.

Developing energy generation and storage technologies based on nanotechnology could solve the future energy problems without causing further harm to nature. There is need to develop planned interdisciplinary and inter-institutional policies and proper regulatory methodologies should be worked out.

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**Corresponding Author: Dr. Mohd. Zahid Rizvi, Department of Botany, Shia Post Graduate College, Sitapur Road, Lucknow-226020, Lucknow, Uttar Pradesh, India.**
**Email: zahid682001@gmail.com**