NANOTECHNOLOGY: A NEW PERSPECTIVE FOR MANAGEMENT OF ENVIRONMENT

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ABSTRACT: *With growing industrialization and increasing population, extended droughts and excessive rainfall, pollution has become the biggest environmental challenge. Moreover, the technological advancement with improper management has also given rise to new pollutants which are increasing at an alarming rate. Hence there is an urgent need to find technologies that would reduce pollution levels in fast and simple ways. Nanotechnology is being explored to provide new solution for detoxification of environment. It can also prevent the formation of dangerous pollutants. In this paper, we discuss the use of nanotechnology for sustainable management of environment and also throw light on how Precision Farming and Energy Generation can be done using Nanotechnology.*

Key Words: *Carbon Nanotubes, nanosensors ,nanodust, nanobiocides, GPS*

I. Introduction

Pollution of air, water and soil is mainly caused by toxic chemicals from industrial and domestic waste, vehicle emissions, excessive use of pesticides, fertilizers etc. It results not only in the destruction of biodiversity, but also severely affects human health. Nanotechnology offers many advantages for pollution control compared with traditional methods. In this sense, nanotechnology can be used for purification, detection of contaminants, and the pollution prevention. Nanotechnology can also used to prevent the formation of pollutants or contaminants by applying the material technology and industrial processes. Thus, the major applications of nanotechnology for protecting environment can be classified as (i) Restoration and purification of contaminated water, (ii) Air pollution detection and control. As shown in fig. (1), Nanotechnology can be used for water and air purification, precision farming, ecofriendly energy generation and soil quality improvement.

We are suffering from a severe water shortage due to irregular rainfall and lack of water management techniques. Biggest rivers are immensely polluted and even their use for irrigation cannot be done. Conventional method of water decontamination such as chlorination and ozonation consume a high amount of chemical agents and, furthermore, can produce toxic byproducts. Due to exceptional characteristics of nanomaterials, they are widely used in water purification and treatment, precision farming, energy generation, etc. Nanomaterials have higher reactivity, larger surface contact and better disposal capability, hence preferred for environmental applications. There are several examples of nanoparticles and nanomaterials that can be used for remediation of water, e.g. zeolites, carbon nanotubes (CNTs) [1], self-assembled monolayers on mesoporous supports, biopolymers, single-enzyme nanoparticles, nanoparticles of zero valent iron (ZVI), etc.

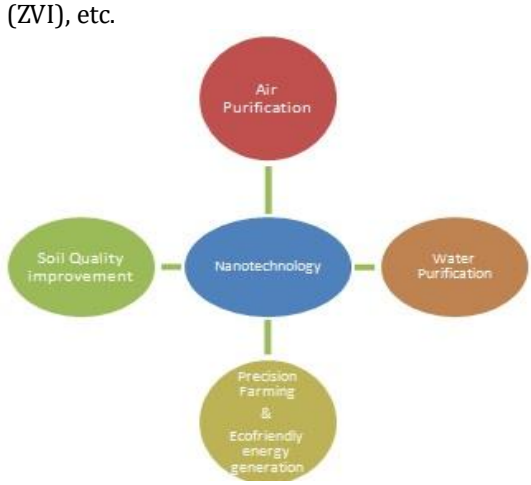

Fig.1 Nanotechnology for Environmental detoxification

II WATER PURIFICATION AND TREATMENT

Innovations in the development of novel technologies to desalinate water are most exciting and promising. Additionally, nanotechnology-derived products that reduce the concentrations of toxic compounds to sub-ppb levels can assist in the attainment of water quality standards and health advisories. Removal of contaminants and recycling of the purified water would provide significant reductions in cost, time and result in improved environment. The total organic carbon from water can be completely removed by addition of TiO_2 nanoparticles in the presence of ultraviolet light. Nanotechnology provides cost effective and environmentally acceptable method of water purification. Impurities like mixtures of metal ions, organic solutes and bacteria can be removed using a simple set up.

US based researchers have developed a sponge made of pure Carbon Nanotubes (CNTs) with a dash of boron that shows a remarkable ability to absorb oil from water. The oil can be stored in the sponge for later retrieval or burned off so the sponge can be reused. Next-generation potable water purification devices equipped with these novel CNTs are expected to have superior desalination, disinfection, and filtration properties. This method can provide potable water by desalinating sea water. Hence sufficient water for agriculture can be made available giving rise to better agricultural yield and farmer suicides can be stopped forever. It would be remarkable advantage of nanotechnology.

Nanofibres and nanobiocides are widely used in water filtration membranes. Nanofiltration membranes provide higher thrust or rejection of multivalent ions, pesticides and heavy metals compared with conventional water treatment methods. Currently, this technology has become the newest and most leading-edge technology in water treatment and is now available for practical use to anybody. Silver nanoparticles Ag NP[2] are highly toxic to microorganisms like viruses, bacteria and fungi hence they have been widely used for the disinfection of water. Ag NPs have been reported to be able to adhere to the bacterial cell wall and subsequently penetrate it, resulting in structural changes of the cell membrane and thus increasing its permeability [2]. Besides, when Ag NPs are in contact with bacteria, free radicals can be generated. They have the ability to damage the cell membrane and are considered to cause the death of cells [3]. In addition, as DNA contains abundant sulphur and phosphorus elements, Ag NPs can act with it and thus destroy it. This is another explanation for the death of cells caused by Ag NPs [4]. With the development of nanotechnology, Ag NPs have been successfully applied in water and wastewater disinfection in recent years. Ag NPs attached to filter materials have been considered effective for water disinfection due to their high antibacterial activity and cost-effectiveness [5].

The silver loss from the Ag NPs sheets used for filtration is found to be lower than the standards for silver in drinking water put forward by Environmental Protection Agency (EPA) and World Health Organization (WHO) [6]. Therefore, for water contaminated by bacteria, filtration through paper deposited with Ag NPs could be an effective emergency water treatment. Besides, Ag NPs synthesized by chemical reduction have been incorporated into polyethersulfone (PES) microfiltration membranes. The activity of microorganisms nearby the membranes was observed to be remarkably reduced. The PES-Ag NPs membranes exhibited strong antimicrobial properties and held great potential in application for water treatment [7].

ZnO NPs are environment-friendly as they are compatible with organisms [8], which makes them suitable for the treatment of water and wastewater. Besides, the photo catalytic capability of ZnO NPs is similar to that of TiO_2 NPs because their band gap energies are almost identical. However, ZnO NPs have the advantage of low cost over TiO_2 NPs. Moreover, ZnO NPs can adsorb a wider range of solar spectra and more light quanta than several semiconducting metal oxides. In recent years, there is a growing interest in the use of iron oxide nanoparticles for the removal of heavy metal due to their simplicity and availability.

III AIR PURIFICATION

Breathing clean air should be a basic human right but we see that populated cities are worstly affected by air pollution. Though there is awareness for plantation of trees which work as lungs of nature, the level of pollution is so high that we need use latest techniques for controlling air pollution. Nanotechnology-based air purifying systems are able to produce huge quantities of clean air. Positive ionization technology is used to clear the surrounding air consisting of dust, finest and ultra-finest particle pollutants, viruses and bacteria. Such air purifying systems can be used in industrial plants, hospitals, schools, restaurants, heavily crowded places like railway stations, temples etc.

Catalysts and nanostructured membranes can be effectively used for air pollution control. Catalysts enable a chemical reaction at lower temperatures or make the reaction more effective. Platinum can be used as catalyst in catalytic converter of four wheeler. The platinum in a catalytic converter helps to change air-

polluting molecules from four wheeler exhaust into less harmful molecules. Use of nanoparticles of platinum increases the surface area available for a reaction and also increases the percentage of platinum atoms available for contact with molecules involved in the reaction. Hence very small quantity of platinum is needed. A rare metal: Rhodium can also be used in catalytic converters of vehicles. Research is going to find whether rhodium-iron or rhodium-copper alloy can be used to achieve same efficiency but at lower cost compared with pure rhodium. These improved catalysts have a better capability to break down air pollutants and also reduce the cost of catalysts used in fuel cells. But platinum comes at a high price, so researchers are working to find alternate material for the same. Nanostructured membranes, on the other hand, are being developed to separate carbon dioxide from industrial plant exhaust streams.

IV RENEWABLE ENERGY GENERATION USING CNT

One of the biggest technological challenges in 21st century is the development of renewable energy technologies due to issues related with the production and use of energy. 90% of our energy demand is fulfilled by fossil fuels. Generation of energy from fossil fuels is major cause of environmental pollution, Hence use of renewable energy which produce light, electricity and heat without pollution is highly recommended to protect environment. Such sources of energy are solar, wind, biomass, etc. Nanotechnology based renewable energy sources help to protect our environment. Today's conventional photovoltaic solar cells are less efficient and are very expensive. These cells lose most of the solar energy striking them as temperature rises. Nanoparticles based technique can be used to produce cost effective and highly efficient solar cells. Carbon nanotubes (CNT) in solar cells and fuel cells increase energy conversion efficiency. Some researchers reviewed the use of 1 D Nanomaterial for improving the efficiency of solar cell. Yuhas and Yang [10] designed a solar cell that combined the ideal geometry of a nanowire based solar cell with photovoltaic components. Solar cells made from nanoparticles of Titanium dioxide are highly efficient. When they are wrapped in specific plastic, the current get amplified automatically. It is light in weight and can work in rainy season also. Some companies have started using glass windows made from solar cells capable of generating energy. Scientists are working on infrared solar cell which is capable of producing electricity even in cloudy weather. CNT, semiconductor quantum dots, polyethylene are the materials used for infrared solar cell. Another material called aerojel can convert entire sunlight falling on it into electricity. Super capacitors using nanotechnology are highly efficient. Energy generation using Nanotechnology is done to reduce environmental pollution. And in near future we can have "Enough energy without pollution" using nanotechnology.

V PRECISION FARMING USING NANODUST

World population has now increased to more than 700 crores. There is a great challenge to fulfill the food requirement of huge population. In India 70 % population is directly dependent on agriculture. Precision farming is essential to increase agricultural yield. Nanosensors can sense very weak audio signals, can detect microorganisms, and can even smell also. These sensors are called as Nanodust. Farmers can get upto date and exact information about various parameters of crop through sensors connected to Global Positioning System (GPS). This information is used to take the necessary action regarding sowing, watering the plants, spraying pesticides etc. Exact time and quantity of water, fertilizer or pesticide required can be decided precisely to avoid wastage and harm to environment. This is called as precision farming. Components of precision farming are as shown in figure (2). The fertility of soil degrades due to excessive use of fertilizers and by taking same type of crop repeatedly. Nanotechnology can find the particular mineral required to improve soil fertility. Iron nanoparticles can be used to improve the quality of soil. Nanotechnology based fertilizers dissolve completely in water hence they are required in small quantity avoiding damage to soil. Nanosensors can also detect the exact amount of water needed by plants and water can be supplied directly to the roots of plants avoiding wastage. The green revolution resulted in excessive use of pesticides and chemical fertilizers which causes loss of soil biodiversity and develops resistance against pathogens and pests as well. Nanoparticle based material delivery to plants and advanced biosensors for precision farming is possible only by nanoparticles or nanochips. Nanoencapsulated conventional fertilizers, pesticides and herbicides help in slow and sustained release of nutrients and agrochemicals resulting in precise dosage to the plants. Nuohumous is a polymer which when mixed with soil can improve water retention capacity of soil. So it is possible to get more yields in less quantity of water. This polymer is biocompatible and hence disappears after its intended function. Biopesticides manufactured using nanotechnology can be sprayed in controlled amount on only affected plants. Hence pollution and its effect on human health can be avoided.

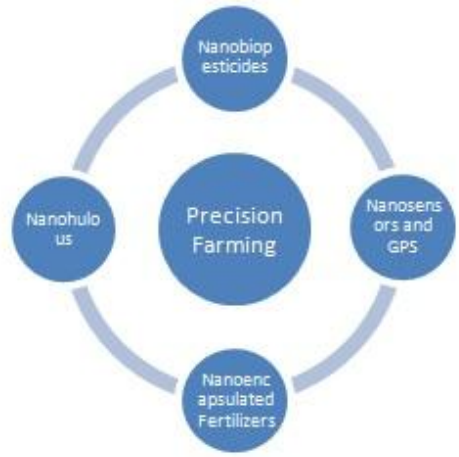

Fig.(2) Components of Precision Farming

Increased food production through excess nitrogen application is responsible for 80% of the increase in atmospheric N_2O (a greenhouse gas) which causes increased atmospheric temperature and thus contributes to global warming [10]. Chemical fertilizers like urea, di-ammonium phosphate (DAP) and single superphosphate (SSP) are used in agriculture to meet the shortage of N, P and K in the soil. Most of the used fertilizers are lost in the environment and can't be absorbed by plant causing wastage of money and efforts at the same time affecting environment badly. A modern approach lies in the use of nanocoated urea or other chemical fertilizers. The stability of the nanocoating reduces the rate of dissolution of the fertilizer and allows slow, sustained release of coated fertilizer which is more efficiently absorbed by plant roots.

Precision farming has been a long-desired goal to maximize output from crops while minimizing the input of fertilizers, pesticides, herbicides, etc. by monitoring environmental variables and applying targeted action. Precision farming makes use of computers, sensors, global satellite positioning systems and remote sensing devices to measure highly localized environmental conditions and helps in determining whether crops are growing at maximum efficiency and precisely identifying the affected crop, its location and types of problems. Ultimately, precision farming with the help of smart sensors will allow enhanced productivity in agriculture by providing accurate information thus helping farmers to make better decisions. This will certainly lead to improved Indian Economy and pollution prevention.

VI CONCLUSION

Nanotechnology is being explored to provide new solution for management of environment by improving the performance of conventional technologies. This technology is explored for combating pollution by reducing the release or preventing the formation of pollutants. It has also shown great potential in water purification and treatment, air purification, energy generation and precision farming. Nanomaterials not only catalyze degradation of waste and toxic materials but it also aids to improve the efficiency of microorganisms in degradation of waste and toxic materials.

If used after proper experimentation, problems of water scarcity, air pollution could be solved to a greater extent. However, there is a risk associated with chronic exposure to nanomaterials and their interactions with biotic and abiotic environment. Despite a lot of research data about nanomaterials are available, the toxicity level of many NPs is still indefinable, thus the application of these materials is limited due to the lack of knowledge of risk assessments and effects on human health.

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