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APPLICATIONS OF NANOTECHNOLOGY IN WATER AND AIR POLLUTION TREATMENT - REVIEW

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Abstract-- Nanotechnology is a forthcoming technology that can offer promising solution for treating pollution by altering size and shape of the material at the nano scale. In general, the nano particles consist of large surface area for pollutant sensing, in - situ remediation and degradation. This review focuses the information regarding the advantages of various available nano materials in water and air pollution control which will help to further addressing of these unique characteristics for sustainable environmental pollution management.
Key words: Water pollution, Air pollution, Nanotechnology, Nano catalyst, Nano adsorbents

I. INTRODUCTION

1.1 Water and Air Pollution

One third of the earth's surface is covered with water i.e. universal solvent but due to their salinity nature, only 2.5% of the world's total water is fresh and available for human consumption and 15% of the total population does not have adequate fresh water to drink and to fulfill their sanitation (Kurniawan et al. 2012). The prime producers of agricultural products including India, China, Israel and the developed countries like North America and Europe are all facing the water problems (Barnett, et al. 2005; Shannon et al, 2008) mainly because of water pollution. Pollutants from residential, commercial, industrial areas and agriculture practices are the major sources of water pollution with results of organic, in organic, pathogenic and non pathogenic microorganisms as contaminants (Sushma and Richa, 2015) which converts fresh water to waste water. A study states that 4 billion diarrhea cases result in 1.8 million deaths per year (Botes and Cloete, 2010). Likewise the presence of very low concentrations of recalcitrant pollutants including heavy metals, nitrsoamines and endocrine disrupters have serious adverse effects on human health and the environment (Schwarzenbach et al. 2006; Kurniawan et al. 2006; Kong et al., 2013).

Similarly, all over the world, especially in thickly populated areas namely India and China, the air pollution is considered to be a very serious problem. Due to the modernization, various types of pollutants emitted from industrial processes or human activities. Examples of some of the pollutants radiated by industries are carbon monoxide (CO), chlorofluorocarbons (CFCs), heavy metals (arsenic, chromium, lead, cadmium, mercury and zinc), hydrocarbons, nitrogen oxides, organic compounds (volatile organic compounds and dioxins), sulfur dioxide and particulates. Likewise by human activities pollutants such as oil, coal and gas combustion have significant potential to change or pollute the natural sources (Fund, 2006).

II CONVENTIONAL METHODS OF WATER AND AIR POLLUTION TREATMENTS AND THEIR LIMITATIONS

The conventional methods of water treatment includes filtration, sedimentation, coagulation, decantation, desalination and disinfection were widely used in early twentieth century. Similarly, the air pollution is prevented by monitoring real time air quality which is currently carried over by the Pollution Control Department (PCD), Egyptian Environmental Affairs Agency (EEAA) (Pummakarnchana, et al. 2005). Developing a successful air pollution control technology requires knowledge on the regulation process along with the type of sources and effluents. The technique may or may not use air pollution control device which converts harmful contaminant to less harmful material. Techniques like change in process, use of less polluting fuel, improve dispersion, good operating practices and plant shutdown or relocation, fuel switching does not require control device.

The major limitations of traditional methods of water treatment includes requirement of large systems, infrastructure and engineering expertise. Further, contamination of fresh water resources by the use of chemicals like chlorine, ammonia, hydrochloric acid, permanganate, ferric salts etc., limits the conventional chemical method of water treatment. Similarly, in air treatment technology requires higher cost vehicle and low vehicle range, cost raise with demand and limited supply. The limitations of both of these methods were tackled by the application of biological treatment. It includes biofilter and bioscrubber. Use of biofilter is the simplest and less expensive method which consists of bed of compost, tree bark, peat, heather, or soil, about 1m deep, through which the contaminant gas is blown. The bioscrubber consists of two units namely scrubber and biological treatment basin. The soluble waste gases and oxygen are continuously absorbed into water in the scrubber. Biological oxidation occurs in the basin unit, which often is the activated sludge basin of a wastewater treatment plant. Bioscrubbers are used where the biological degradation products (such as the acids produced during H_2S and NH_3 removal) would harm a biofilter bed. In addition to hydrocarbons, bioscrubbers are being used to remove chlorinated organic materials. But these methods are also having their own disadvantages includes identification of microorganism for the specific application, compost mixing treatment, appropriate design and operational conditions etc., (Soccol et al. 2003). Hence there is a demand for effective and low cost promising techniques of water and air treatment.

2.1 Emergence of nanotechnology in water pollution treatment

Three important applications of nanotechnology in the fields of pollution control can be classified as (a) remediation and purification of polluted material, (b) pollution detection and sensing (c) pollution prevention (Yunus, et al. 2012). The applications of nanotechnology have a great potential in prevention and treatment of pollution in water (Kumar et al. 2014). It helps to detect and to remove contaminants which include organic and inorganic solutes, heavy metals (mercury, lead, arsenic and cadmium) and biological toxins easily from environmental sources with low cost (Doroodmand et al. 2012).

2.2 Emergence of nanotechnology in air pollution treatment

Many studies reveal that the relation between rate of mortality and morbidity (based on respiratory ill health) were increased with respect to air pollution by ultrafine particles (Stone, et al. 2007). From the past twenty years, scientists take a tool of nanotechnology to solve problems in medicine, computer science, ecology, electronics, food, clothing, cosmetics and sporting. Current research at the nanoscale level develop novel, highly effective, low cost efficient methodologies for pollution remediation, detection and analysis, catalysis etc. In order to monitor, to detect and to treat air pollution, currently the advancement of nanotechnology offers a promising solution to develop a cost effective and rapid system. For example, the solid state gas sensors (which control the ventilation) are widely used to monitor and to detect the fire and toxic gases. Now a day, the nanosensors are integrated with the solid state sensor called hybrid sensor. This hybrid sensor connected with Personal Digital Assistant (PDA) as well as communication tools like Bluetooth, Geographical Information System (GIS) and Global Positioning System (GPS) are used to monitor the air pollution level in industry (Ramadan et al 2009). Similarly, to reduce air pollution nanosized catalyst and nanostructure membrane are effectively used.

III. APPLICATIONS OF NANO MATERIALS IN WATER AND AIR POLLUTION TREATMENT

3.1 Nano adsorbents:

Carbon nano tubes (CNTs) possess increased adsorption competence for metal ions than the activated carbon. The graphitic surface of the CNT donates electrons to form hydrogen bond with the organic compounds having carboxylic, hydroxyl and amide functional groups (Pan and Xing, 2008; Prachi et al. 2013). Similarly, for heavy metals and radio nuclides, the nano scale metal oxides like ferrous oxide, TiO_2, $Al2O_3$ are good adsorbents (Mayo et al. 2007).Likewise to remove organics and heavy metals, dendrimers were used effectively (Diallo et al., 2005). Further, these carbon nano tubes (CNT) separates methane and carbon dioxide from exhaust through their different pore size and traps the greenhouse gases which are emitted during coal mining and power generation (Chirag, 2015).

3.2 Nano membrane:

Prior to ultra filtration or reverse osmosis, the nanocompoiste membranes were used as prefilters having increased surface hydrophilicity, water permeability, or fouling resistance. This is achieved due to the addition of nanomaterials of alumina (Maximous et al. 2010), silica (Bottino et al. 2001), zeolite (Pendergast et al. 2011) and TiO_2 (Bae and Tak, 2005) to polymeric ultra filtration membranes (Ramakrishna et al. 2006). Similarly, the inhibition of bacterial attachment and biofilm formation were achieved with the doping of nanosilver on polymeric membrane surface (Mauter et al. 2011).

3.3 Nano catalyst and catalytic membrane

The zero valent metal and bimetallic nanoparticles were widely used as catalyst which removes the contaminants like organochlorine, herbicides, pesticides, azo dyes biphenyls and nitro aromatic compounds from water sources (Chaturvedi et al. 2012). Similarly, many volatile organic compounds, acetaldehyde, toluene, hexane, nitrogen and sulfur were removed effectively by using gold nanoparticles in manganese oxide (Sinha, et al. 2007). The catalytic membrane has similar catalytic sites which enhance the attachment and favors the multiple ordered reactions. It is achieved with TiO_2 nanostructure membranes (Tarabara, 2009).

3.4 Bioactive nanoparticle and biomimetic membrane

Bacillus cereus was widely used to synthesize silver nanoparticles as antibacterial. Similarly, both the positive and negative spores were removed with the MgO nanoparticles and cellulose acetate fibers embedded with Ag nanoparticles (Prakash et al. 2011). Further, the biomimetic membranes consist of increased permeability and selectivity with great degree of salt removing property (Kaufman and Freger, 2011).

IV. CONCLUSION

All over the world, there is an increasing demand for clean and safe environment with increased awareness about the health. An application of nanotechnology in environmental pollution treatment offers a potential to overcome the high cost and technical capacity hurdles to current and future generations. The advancement of science and technology provides highly efficient techniques for the environment pollution treatment in near future. However, gaining of knowledge on the toxicity nature of these nanoparticles on environmental living organisms limits their commercialization. In order to bring this technology as commercially viable, the safety guidelines includes toxicity screening of engineered nanoparticles under environmental conditions should be enforced by nanotechnology industries.

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