Nano Technology in Environmental Application

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ABSTRACT

With the advent of modern technologies and advanced process, industries had grown by leaps and bounds. Rapid industrialization had in over exploitation of our resources leading to security, simultaneously discharging the pollutant into the environment beyond its assimilative capacity. The impact of such continual exploitation and pollution had lead to the contamination of our water bodies, land and ambient air with toxic compound, which is now threatening the very survival human and other living beings. Maintaining and improving soil, water, and air quality represent some of the most formidable challenges facing global society in the 21st century. Pollutants from such diverse sources as oil and chemical spills,pesticide and fertilizer runoff, abandoned and mining sites, and airborne gaseous an particulate matter from automobile emission and domestic wastes, municipal and industrial solid gets accumulated in the environment. Detecting and treating existing containments and preventing new pollution are amongb the challenges. The aggregate financial burden for improving air, water , and soil quality is truly staggering. In fight of these enormous and complex challenges, it is perhaps ironic that one prospective solution is minute in size but massively powerful in capacity nanotechnology. The remediation of contaminants by use of existing technologies will not be effective enough to meet the futuristic environmental standards and needs innovative advanced technology. Environmental nanotechnology would be a new technology to remediate and treat the contaminants to the acceptable level. Environment scientist are working with nano-scale structure of manipulating matter at the atomic or molecular scale that has cut across such disciplines as chemistry, physics, biology and engineering. Deposit a largely unproven track record in the environmental area, Nanotechnology offers great promise for delivering new and improved environmental technologies. However, proliferation of nanotechnology could also lead to new environmental problems, such as a new classes of toxins or relatedenvironmental hazards.

Natural weathering of minerals, such as iron oxides and silicates, and microorganisms, such as bacteria and algae, produce nano-scale collides, which include dispersion of nano sized- particle in media with special properties that can be important in the fate, transport, transformer, and bioavailability of environmentally harmful substances.

Key words: Nanotechnology, Environment, Nano particle, TDS, Membrane Technology, Zero Discharge, Remediation, Sensors.

1.0 Introduction

Nanotechnology are the design, production, characterization and application of structures device and systems by controlling shape and size at nano meter scale (1-100 nanometre),andexploitation of novel phenomena and preporties and exploitation of novel phenomena and properties (Physical, chemistry, biological, mechanical, Electrical) at the length of scale. The prefix ‘nano’ is derived from the Greek word for dwarf. One nanometre (nm) is equql to one billionth of a human hair. A scientist and technical revolution has just begun based upon the ability to systematically organise and manipulate matter at nanoscale, The research work focuses on experimental research and development in nano and bio technologies. Nanotech is even expected to help us heal the damage our past cruder and dirtier technologies have caused to the biosphere. Nanotechnology has been identified as essential in solving many of the problems facing humanity. Nanotechnology is likely to change the way almost everything, including medicine, computers and cars, are designed and constructed. As television, aeroplane and computer revolutionized the world in the world of last century scientist claim that nanotechnology will have an even more profound effect on this century. Atom and molecule stick together because the have complementary shape that looks together, or charge that attract. Just like with magnet, a positively charge atom will stick to a negatively charged atom. As millions of these atoms are pieced together by Nano machine, a specific machine will begin to take part shape. The goal of Nanotechnology is to manipulate atoms individually and place them in a pattern to produce a desired Structure.

Nano in Bio: - Medicine the unique optical, electronic, Structural properties when added to biomolecules will result in powerful new medical treatments and diagnoses

Bio in Nano:-Materials/Devices Manipulation and assembly of nanostructure into material and

functional device using machinery will enable new technologies.

Nano-Bio in our Environment: -**Responsibility** Risk Assessment/Reduction

2.0 Environmental Processing (Existing)

The conventional environments remedial see to be relatively ineffectual the present content of extensive and expending pollutant load that permeate the air water and soil environments. Most of the existing effect treatment plant produces effluent, which are unable to adequately treat it to disposal standard. Since most conventional ETPS employ neutralization, coagulation, clarifications using either alum or ferrous sulphate followed by extended aeration. TDS level in the treated effluent of this type are much higher than discharge standard (2000 mg/lt) pre3cribed by the pollution control board. To assist industries in the total water management endeavours, recherché have develop for recovery of reusual water from effluents. Some of the available technologies:

1. Membranetechnology
2. Nano technology

2.1 MembraneTechnology

After chemical treatment of the effluent , it is aerated and filtered through series of filters like sand (remove suspended substance), activated carbon (remove ordureand colour) micro filters, ultra filtration filters (remove micron particles bacteria) After removing the contaminants the water vis fed into the RO membrane capsule with high pressure. In this we got two stream of water and one is 90% permeate, which is pure water with less TDS around 30 to 100 mg/lt. And another one stream is 10% REJECT contains high Tds around 20000 to 25000mg/lt, according to the quality of feed effluent water RO reject through small volume, will be much more polluting in nature with immediate and irreparable impact on the environment. To prevent the discharge of RO reject as it is, a capital intensive, high in operation and maintenance cost multiple effect Mechanical Evaporator are installed.

Mechanical Evaporator recovers about 95%of as water from the RO reject and the remaining 5%of water will be present along with concentrated salt slurry which could be dried to provide more hazardous salt powder. Thus we are achieving ZERO DISCHARGE.

2.2 Environmental Nanotechnology

One of the emerging technology is Nanotechnology. Nanotechnology dedicated for environmentalclean-up may evolve to levels of sophistication and efficiency, such that contaminated affected areas might well be engineered or reset to original integrity and ecology balance. Nanotechnology in particular plays a significant role in current efforts to develop better methods for detecting and decontamination of harmful biological agents. Nanotechnology in environment is one among the numerous promising applications.

2.3 Environmental applications of Nanotechnology fall into three categories

Environmental protection (pollution prevention)

Environmental remediation (to clean the contaminated sites)

Environmental sensors (To control the process)

2.4 Environmental Protection

Nanotechnology provides way to reduce the use of manufactured material minimize or eliminate the waste generation and reduce the toxicity. Nanotechnology effectively tretes waste streams and remediates existing polluted sites. Environmentalistexploit the nanoparticle role in making products and process more compatible to environment by making use of size and shape, dependent optical and electronic properties of nanoparticle.

Nanoparticles have been studied for oxidation for oxidative and reducing transformation of organic and in organic species present as contaminated in air and water. Nanostructurecatalyst makes chemical manufacture more efficient by providing higher selectivity for desired reaction products.

a) Amino silicate molecular sieve are porous crystalline solid used for separation as catalyst

b) Nanometre Zeolites (10-100nm) are being developed to selectively oxidized hydrocarbon such as toluene, Benz aldehyde

Nanotechnology application could also help to create benevolent that replace currently used toxic chemicals.

Example; CRT computer monitor cathode ray tubes contain many toxic material. But it is replaced bynontoxic energy effect liquid crystalline display monitors(LCD) usingcarbon nanotubes in computer

,may further diminish the environmental impact by eliminating Toxic materials.

3.0 Remediation

Hazardous toxic contaminates such as heavy metals (e.g. Lead, cadmium, mercury, etc) and organic compound (e.g. Benzene, xylene, toluene solvent and pesticide) pesticide in environment are targeted for remediation. Nanoparticles are more reactive and react to a greater extent due to their small size and large surface area available for chemical interaction. Due to their usual crystal shape and lattice order, nanoparticle exhibit higher chemical reactivity. Varity of nanoparticle are being explore to remove or destroy toxic substance (pollutants) presence in environment.

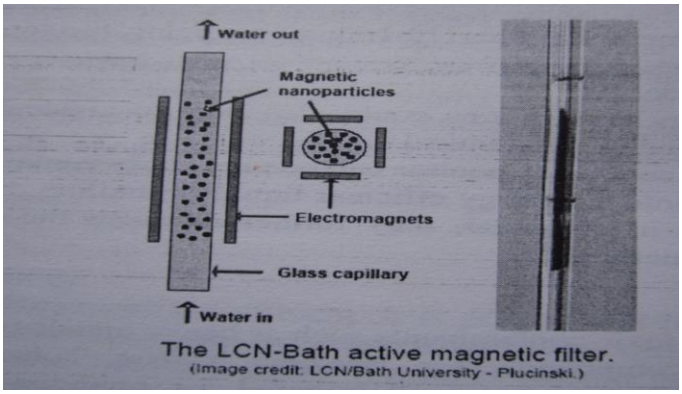
1. Nanotechnology-Dense Non Aqueous Phase Liquid

Developed stabilized suspension of nano-scale magnetic (FeSo4) particle for the remediation of ground water contaminated with carbon tetrachloride.

2. Nano Technology-Water remediation

Clean water is essential for safeguarding public health, but just how to clean our water? The answer is not clean as we would like, when it comes to powerfully harmful chemical that can affect our health even hey are present at the part-per-billion level. Endocrine disrupting substance (EDS) falls in to his category of, to put in to mildly problematic chemical group.

The key to achieving this objective is to develop a safe, simple, cheap and effective solution that work equally well on a lab bench and in a full scale water treatment plant. We propose to adapt a ground breaking new techno, the Magnetic Filter (AMF),to the problem. The AMF has very recently been development by group at the LCN and the University of bath. Nanoparticle (such as iron oxide) with diameter in the range 10-30 nm are relatively easy to synthesize, and can be functionalize-meaning that they can be coated with various types of organic molecule or proteins. These coatings can be designed to react chemically, and to bind specifically to target molecule –in our case the harmful EDS molecule. Because of their very small size , nano particles have a very large surface area to volume ratio, so that they are extremely efficient carries of surface-conjugate organic molecules. Magnetic nanoparticles can be mechanically actuated(moved) by the action of externally applied magnetic field gradient. If the external field is made to change it's the direction with time. The nanoparticle will moved to follow the changes-this can beused to generate a 'stirring' of the nanoparticles. A given target molecule in a fluid passing through this moving slurry wiil have a greater chance of binding to a receptor molecule(on one of the nanoparticles) then immobile filter Researches are going on this area to develop commercial exploitation, which can benefit the society for purification, protecting the public health from harmful pathogens and chemical toxicant.



The LCN-Bath active magnetic filter.
(Image credit: LCN/Bath University - Plucinski.)

3. Nano Technology-Microbial Remediation Techniques

Microbes such as pseudomonas play a role in many different content such as degradation of pollutants. Typical pseudomonas bacterium in nature found in biofilm, attached to some surface or sustrate or as a unicellular organism. Using this scientist aim to develop a fundamental understanding of how biofilm and related biodegradation activity respond to enviromental conditions. And investigating the generic control of cell attachment to solid surface;.This will assist in achieving the overall aim of the cell mineral –interface program in understaning the intraction between the component of complex underground system, comprising minerals, water microbes an pollutant to predict and potentially manage biodegradation activity within the contaminated aquifire and soils.

4.Nano Technology-Protein Based Nanoparticles Remediation:

Using protein structure to design and assemble metal oxide nanoparticle that could be used in environmental remediation .FERRTIN, an iron storage protein in our blood stream is used for creating nanoparticles. Similarly strogin and his collaborators have been loading horse spleen ferrtin with iron loaded, we can very the size of the nanoparticles. By applying these nano-particles, with the aid of visible light or solar radiation,able to

reduce the chromium from hexavalent to trivalent state which is isolubble. Trivalent chromium is much easier to clean up and less toxic. Thus created nanoparticle will also have an impact on other toxic metal too which is under study.

5. Nano Technology-Adsorption and Oxidation Reaction Remediation:

Self-assembled monolayer on mesoporous support (SAMMS) is a prominent example of a nano technology for contaminant remediation by adsorption. SAMMS are created by nano layer of functionalized surfactant on to mesoporous ceramic supports , resulting in very high surface areas(approximately 1000m^2/g) with adsorptive properties targeting contaminants such as mercury,

Chromate, arsenate, and selenite.

Another nanomaterial called deontic polymer enhanced ultra filtration to remove cu (II) from and washing to remove Pb (II) contamination.

6. Nano Technology-Iron Particle-Remediation:

Nano iron particle , a new generation of environmental remediation technology, gives cost effective solution to some of the most challenging environmental cleanup problems. It has large surface area and high surface reactivity. It shows very effective detoxification of common active contaminants such as chlorinate organic solvents, pesticides. It is inexpensive and nontoxic.

Two factor contribute to the nanoparticles" capabilities as an extremely versatile remediation tool. The first is their small particle size(1-100nm). Nanoparticle can be transported effectively by flow of ground water.Due to this nanoparticle water slurry can be injected under pressure and or by gravity to the contaminated plume where treatment is needed. The nanoparticle can also remain in suspension for extended period of time to establish an in situ treatement zone (about 48 week).For example, nanoparticle are easily deployed in slurry reactor for the treatment of contaminated soils, sediments, and solid wastes. Alternatively, nanoparticles can be anchored onto a solid matix such as activated carbon and or zeolite for enhanced treatment of water, wastewater, or gaseous process stream.

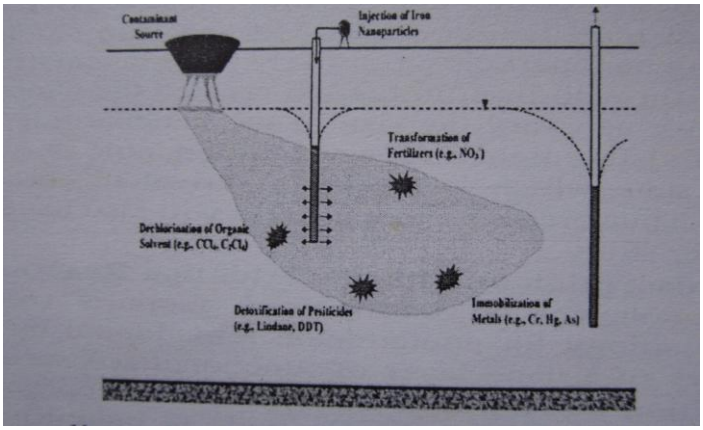
Direct surface injection, whether under gravity fed or pressurized condition, has already been shown to effectively transform chlorinated organic compounds (Elliott &zhang, 2001; Glazir et al., 2003).The technology hold great promise for immobilizing heavy metal and radio nuclides as well. Metallic or zero valent iron (Fe0) is a moderate reducing reagent, which can react with dissolved oxygen (DO) and to some extent with water.

2FeO(s) + 4H(aq) + O2(aq) -> 2F2 + (aq) + 2H2O(1)(1)

FeO(s) + 2H2O (aq) -> Fe2 + (aq) + H2 (g) + 2OH-(aq) (2)

The above equation are the classical electrochemical /corrosion reaction by which iron is oxidized from exposure to oxygen and water. The corrosion reaction can be accelerated or inhibited by manipulating the solution chemistry or solid (metal) composition. Contaminant such as tetrachloroethen (C2CL4),a common solvent, can readily accept the electron from iron oxidation and be reduced to ethan in accordance with the following stoichiometry:

C2Cl4 + 4FeO + 4H + -> C2H4 + 4Fe2+ + 4CL- (3)



Environmental application of metallic iron has been enthusiastically accepted by many user and regulatory agencies, largely due to the low cost and absence of any known toxicity induced by the use of iron. Rapid and complete dechlorination of all chlorinated contaminants was achieved within the water and soil water slurries.

Recent research suggested that as a remediation technique, nanoscale iron particle have several advantage:-

- Effective for the transformation of a large varity of environmental contaminants,
- Inexpensive, and
- Nontoxic

4.0 Sensors

Nano-sensors enhance our ability to identify the source and strength of contaminants determine the route and mechanism of environmental rate and bio divers ability to access the effectiveness of the treatment and remediation techniques. Nano technology has made it possible to develop nan sensor for efficient detection of pollutants and specific pathogens in environment. Nanosensor are used to for monitoring or process control to detect to minimize the impact of pollutants of the environment. Sensors are developed to detect ppm to ppp level of heavy metals organic contaminants from air and water and dioxins. Recent year many sensor have been developed.

SiO2 based semiconductors system used as conuctometric gas sensors

TiO2 based electrode used for determining the chemical oxygen demand of water

Protein biochip (mating silicon complete chip with biological protein) sense the low concentration of target substances and organisms. Future chip containing thousands of nanoscale protein could quickly and cheaply detect specific microbes cell and harmful chemicals.

5.0 Nano Technology In Environmental Applications: In a nutshell

In Treatment- cleaning up waste streams of highly toxic contaminants which is difficult to eliminate.

In Remediation – clean up the contaminants site with problem brought about by previous practices.

In Sensors – Improving monitoring and better controlling.

Green Manufacturing – atom by atom construction of nanoparicles (less material waste) elimination of waste product by designing in pollution prevention at source using nanotechnology.

Green Energy – Solar and fuel cells that use nanomaterial, Energy saving via light weight composites embedded systems.

Nano Technology –Scope For Future Research:

Recent thrust in this area has been the exploration of the size and the shape properties of semiconductor and metal. To organize the molecule /atom into assemblies so that the properties of the produced nanoparticles are tailored to application. Contamination caused during manufacture / application of nanomaterial major concern. We have to design the eco-friendly protocol like to the regulation for manufacture and use of the other chemical and material. The research is needed to design new technologies and optimize existing technologies to solve most challenges facing environmental and material engineering today.

These include:

- Optimizing radioactive clean-up technologies through modelling the effect of electron transfer on uranium organic complex.
- Using fictionalized carbon nanotubes in intransitive electrochemical sensors.
- Developing new safe and effective technologies for remediation of contaminated structure.
- Characterizing the interaction of toxic metal with bio micro molecule to better understand the nature and fate of mixed waste.
- Studying the chelation of pollutant through state of the all quantum mechanical molecular modelling and density function theory.
- Using protocol for environment remediation.

To under interaction between the environment and natural and human made material it is essential to have knowledge of nanoscale material. We need to create new methodologies and research technologies that will provide the necessary combination of tools, software and knowledge for environmental problem solving. Law of quantum mechanics often cause dramatic changes in the mechanical, optical, chemical and electronic properties of material on nano scale. We need to create sensors for improved monitoring and detection capabilities, treatment and remediation technique for cost effective and elimination of generated waste products.