MINIMISING ENVIRONMENTAL EFFECTS OF NANOMATERIALS, A REVIEW

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ABSTRACT

Nanomaterials play very important role in chemical industries, agrochemical products, pharmaceutical drugs, materials science, engineering and nanotechnology. There is a recent increase in the utilization of nanomaterials for food and nutraceutical materials, energy, biomedical, cosmetics, textiles and health products. Nanotechnology is a potential area that revolutionises almost every sector of life and is predicted to become a major economic force in the near future. Nanomaterials are dispersed or solid particles with a size range of 1-100nm. Toxicity and ecotoxicity of some nanomaterials are well known. Their discharge into the environment pose serious threat to human life and environment. As such, it has become imperative to have a critical evaluation of the current states of knowledge with respect to the exposure and effect nanomaterials on the environment. The present review focused on reducing environmental problems associated with production, utilization and waste products disposal of nanoparticles. Sequel to environmental challenges posed by the use of nanomaterials in nanotechnology, efforts should be geared towards environmental remediation, efficient conversation of biomass, green chemistry, mandatory report of information about nanomaterials, modeling approach specific for NMs as well as standardized guidance describing specific requirements for the testing of fate and effects of Nanomaterials.

Keywords: Nanomaterials, Environmental Challenges, Green Chemistry, Remediation.

Introduction

Nanotechnology is a multidomain filed which covers diverse fields like engineering, agriculture, technology, physics, chemistry, biology, materials science, architecture, medicine and pharmacy. Nanomaterials (NMs) contain at least structural dimension at the nanoscale(1nm-100nm) with unique physicochemical properties of abundant surface atoms and significant surface-to-volume ratio (Toma, 201 Charitid e

significantly improved but sometimes unpredictable physical, chemical and biological properties different from their bulk materials. Nanomaterials also differ from bulk materials in parameters such as physical strength, reactivity, electrical conductivity, optical features and magnetism (Kabir *et al,* 2018; Chaudhry *et al,* 2018).

The unique properties of NMs make them applicable in diverse fields such as energy, catalysis, pharmaceuticals, environmental protection, biomedics, cosmetics, textiles, electronics and optical instruments, food and agriculture. The application of nanotechnology in agriculture presents significant, new opportunities for developing more effective fertilizers and pesticides that may have reduced imparts on the environment (Walker *et al*, 2018; Charitides *et al,* 2017; Fahimirad *et al*, 2019; Adebisi *et al,* 2019; Azeez *et al,* 2019)

Nanomaterials are synthesized by chemical, physical and biological methods. Although the synthesis by nanomaterials by physical and chemical ways is quite frequent but the use of toxic chemicals limits their applications. However, the NMs synthesized by biogenic approach shows good polydispersity, dimension as well as stability. In

pressure, it is also cost effective and ecofriendly (Fahimirad *et al,* 2018; Charitidis *et al,* 2014; Toma, 2013; Khan, 2018).

For application of nanotechnology in various fields, a number of concerns remain including uncertain ecological impacts, environmental soundness, fouling properties, low detection limits, high expenses, regeneration and environmental deposition (Walker *et al,* 2018; Kabir *et al,* 2018). Despite the progress in NMs technology, information regarding the possible effects of NMs on the human health is yet insufficient. Since NMs may not be detectable after discharge into the environment, they can cause various types of environmental problems if remediation plan is not secured. Additional study is therefore required to systematically explain the structure function relationships of NMs with respect to their fundamental chemistry like functionality and toxicity (Walker et al, 2018; Kabir *et al,* 2018; Charitidis *et al,* 2014). There is also a lack of emission factors of the nanomaterials into different environments (air, water, soil). The lack of information about the life cycle of nanoparticles results in the ignorance towards potential environmental problems (Charitidis *et al,* 2018).

The research and applications of nanotechnology are advancing mainly due to valuable properties of nanomaterials and the products manufactured. In the process, there is a growing concern about the impact of nanomaterials on the environment, release of hazardous nano wastes into the environment, nanomaterials waste disposal and better ways of utilizing nanotechnology in solving environmental problems. In this review, we have explored the potential application of green chemistry and green biotechnology to reduce environmental challenges posed by applications of nanotechnology.

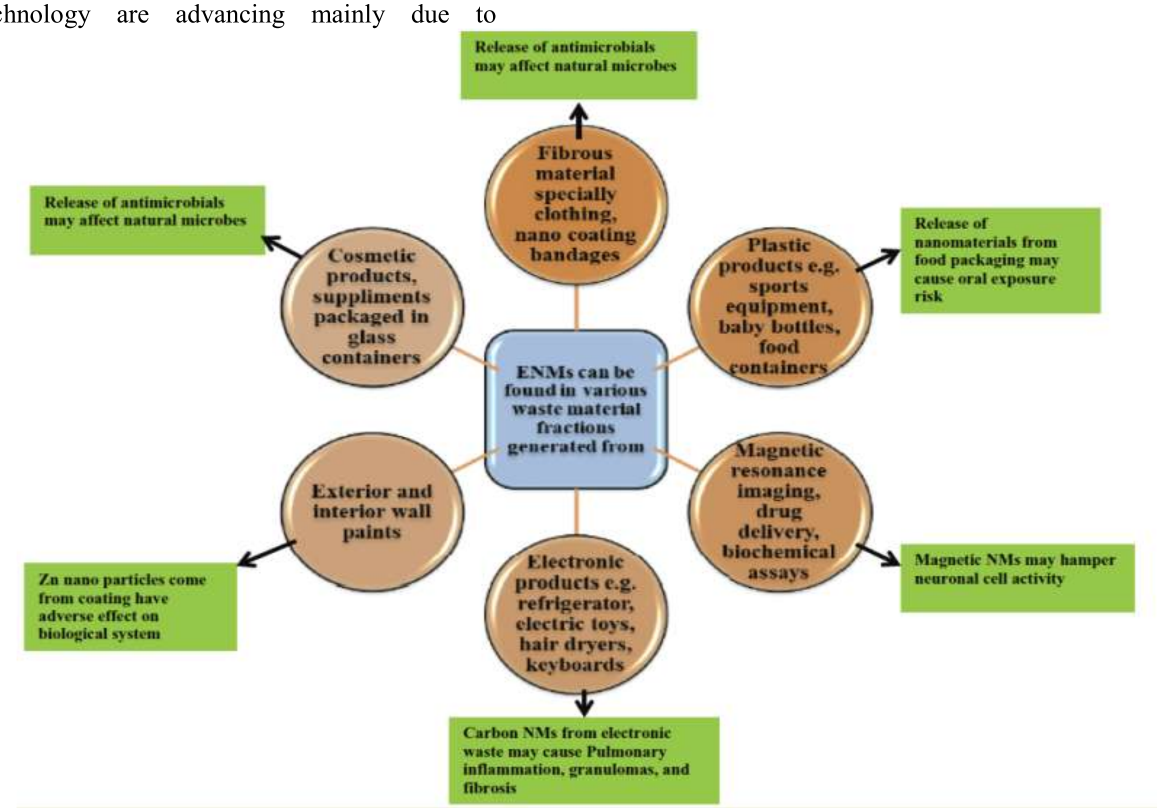

Fig 1. Sources of Engineering Nanomaterials

Application of Nanomaterials

During the last decades, nanomaterials have played an ever increasing role in the material science field and are nowadays commonly found in our daily lives (Wahauser *et al,* 2018). Studies in the past several years showed that nanotechnology has the ability to bring revolution in the field of agriculture, food and health sectors with the application of biosensors, plant growth regulators/parameters, food supplements, enhancement of plants and animals by genetic means smart delivery agents for drugs, pesticides (Chaudhry *et al,* 2018). Khan et al (2018) noted that cellulosic nanomaterials (NMs) have found applications in food and nutraceutical applications. They are used as emulsifier for emulsion stabilization; immobilization of bacterial and mammalian cells, immobilization of enzymes, immobilization of bioactive agents, intelligent packaging, removal of toxins, such as a flatoxin, mycotozin among others from food products. CNMs also find application as a direct additive or a formulation in food preparation.

Silver nanoparticles (AgNPs) is one example of the most efficient nanoparticles for biological applications including therapeutic goals, biomolecular detection, drug delivery, food production, antibacterial agents and agricultural purposes (Fahimirad *et al,* 2018). It has also found applications in textiles.

Catalyst plays a very important role in the chemical industries. Nanocatalyst improves the selectivity of the reactions by allowing reaction at alower temperature, reducing occurrence of side reactions, higher recycling rates and recovery of energy consumption. They are therefore widely used in green chemistry, environmental remediation, efficient conversion of biomass, renewable energy development and other areas of interest (Sharma *et al,* 2019; Revathy *et al*, 2018; Wu *et al*, 2018).

High performance carbon/MnO_2 Micro/nanomotors have been used to remove environmental pollutants from water (He *et al,* 2019). They could move with ultrafast speed and disperse in water without the addition of surfactant. High pollutant removal efficiency was achieved for both methylene blue and Ag ions within 15 minutes. Govindhan *et al* (2014) observed that owing to the high toxicity and detrimental effects of chemical contaminants to human health and the environment, public concerns over chemical contaminants in the environment and in foods have been mounting drastically. The application of the state-of-the art nanomaterials through the incorporation of carbon nanomaterials, metallic oxide nanoparticles, titanic dioxide nanotubes and dendrimeters towards the development of electrochemical sensors for detecting contaminants in the environment and foods is significant. Santiago (2018) stated that progress in nanotechnology has enabled the synthesis of active particles that can harness chemical energy and translate it into useful work.

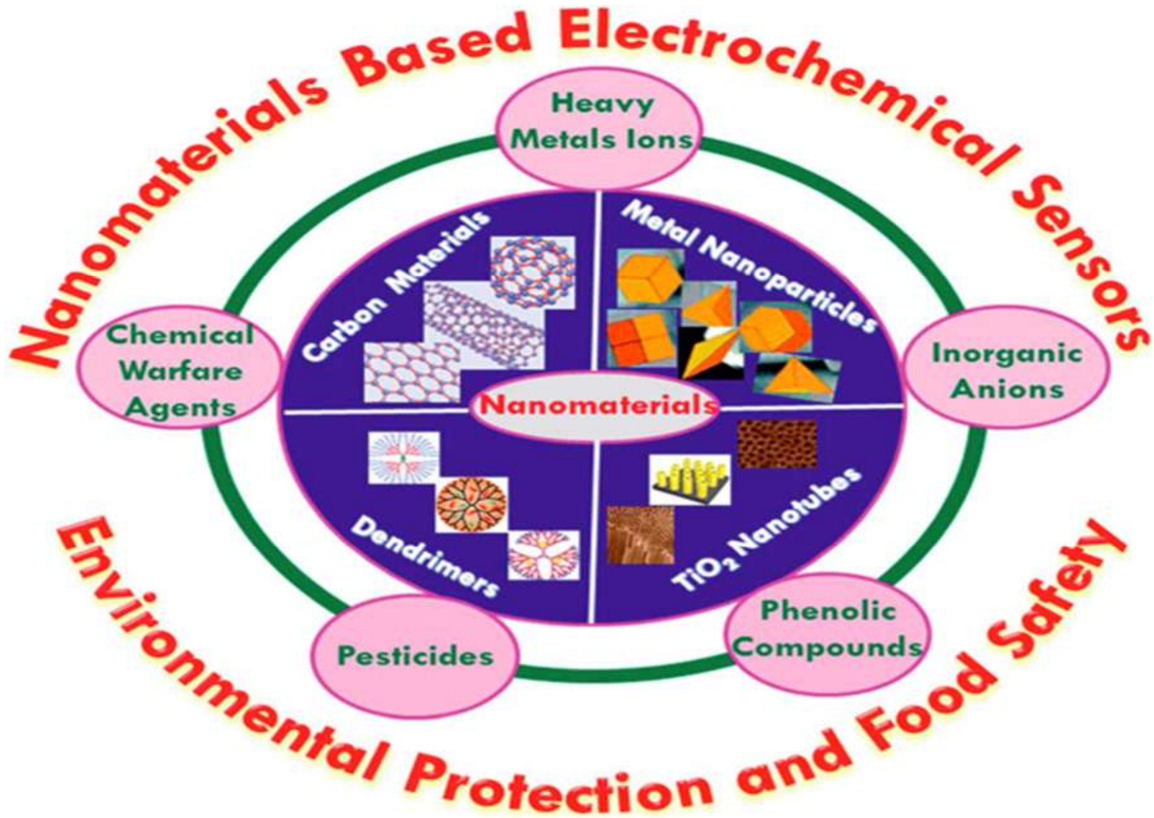

Fig. 2. Electrochemical Detection of Chemical Contaminants with Nanomaterials.

Toxicity and Environmental Effects of Nanomaterials.

One of the major factor affecting the application of NMs, is the concern over safety and toxicity of these nanomaterials. Due to their unique properties (e.g extremely small size and high surface-volume ratio), the impacts and toxicity of NMs on the environment with respect to their interaction with biological substances are still relatively poorly described (Khan *et a,l* 2018), Kabir et al, 2018). The destiny of NMs in the environment is controlled by the combined effects of their physicochemical and their interactions with other pollutants. NMs found in the environment can come from various natural activities (volcanic activities, forest fires, soil erosion, weathering, clay material and dust storms or from intentional/unintentional fossil fuels, mining/demolition automobile traffic and NMs production and waste stream. After NMs are discharged into the environment, they accumulate in different environmental matrices. For example air, water, soil and sediments (Kabir et al 2018; USEPA, 2016). Since NMs are highly reactive, even the properties of NMs in environmental samples could change between collecting and analyzing the samples. After the release of NMs to the environment, they may interact with other pollutants to form a mixture of materials. The presence of NMs was also demonstrated to exert low to high toxicity impacts on the aquatic life. Toxicity study revealed that Nms may affect unicellular aquatic organisms and creatures like fish and Daphnia (Kabir *et al,* 2018; Khan *et al,* 2018; Voelker *et al*, 2015). Nanomaterials are also reported to exert negative impact on the air system. The NMs played an import role in the formation of dust clouds after being released into the environment. The negative impacts of NMs and ENMs on marine animals, microorganisms plant soil, water, and air are well known (Walker *et al*, 2018; Kabir *et al,* 2018)

There is a growing concern regarding the toxicity and exposure of NMs as they can pass through and absorb in the cell membranes of mammalian. Exposure routes are diverse and include oral, dermal, inhalation, and/ or gastrointestinal tract while using products such as sunscreen, skin care products, paints and coatings products, food and health supplements food additives and food colourings (Kabir *et al,* 2018; Walker *et al,* 2018; Voelker *et al,* 2018; Khan *et al,* 2018).

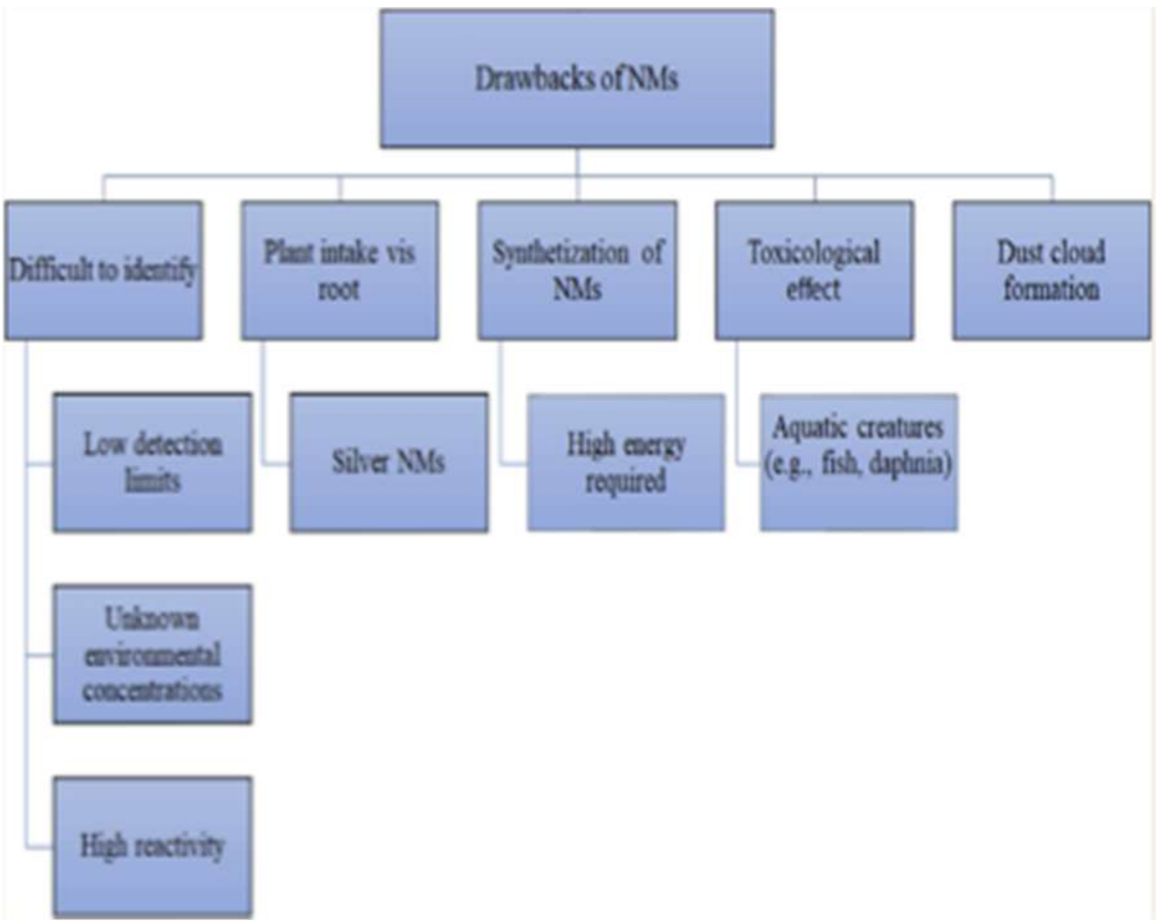

Fig. 3: Drawbacks of Nanomaterials

Reducing Environmental Effects of Nanomaterials

Sequel to the rapid emergence of materials and products designed using nanotechnology, concerns have escalated regarding the potential for adverse environmental effects. Traditional waste management methods should be replaced due to the advances in nano-ecotoxicology that can detect trace levels of nanowaste. Therefore, it has become critical to evaluate the toxicity and environmental concerns associated with NMs exposures. In order to reduce the potential health risks, eco-friendly approaches for the nanoparticles production should be given a great deal of attention. Green nano-chemistry follows fundamental objectives such as developing protocols to produce safer substitute materials compared to thosecourentionally applied and subjected to different levels of concerns to be toxic or bioacaimalative. Green chemistry approaches for NMs synthesis are one-step, fast, simple, low cost, avoid toxic chemicals, water (Fahimirad et al, 2018, Toma 2013). There should be a trend in the research community in a quest to find natural nanomaterials, with green/energy efficient preparation processes (as an alternative to synthetic nanomaterials). There should also be an increased demand from consumers industries and governments to shift focus from synthetic nanomaterials to notoxic and green nanomaterials. If is also imperative to conduct risk quotient determination, environment risk assessment, mandatory reporting of important information, modeling approaches specific for nanomaterials as well as standardized guidance describing specific requirements for the testing of fate and effects of nanomaterials. Green chemistry principles, demand new strategies to generate sustainable industrial process including new chemistry, new process design and new equipments. Along these lines, the association between nanotechnology and green chemistry can be highly rewarding.

Conclusion

The development and implementation of industrial processes should depend on environmental, economic and societal factors. Since continued breakthroughs have been made in the application of nanomaterials in diverse fields, there should be a concern over their effects on the environment. Risk reduction and risk management options should be seriously considered. Good application practices should be imbibed by the stakeholders in nanomaterials application. Recovery, recycling and reuse of nanomaterials wastes could offer attractive means of minimizing environmental effects of NMs. Utilizing green chemistry in the various stages of production of NMs could serve as environmental remediation purposes. It would also promote better and sustainable industrial processes.

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