International Journal of Scientific Research in Physics and Applied Sciences
Vol.6, Issue.6, pp.155-158, December (2018)
Review Paper
E-ISSN: 2348-3423

Nanotechnology towards Sustainable Agriculture

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Available online at: www.isroset.org

Received: 17/Oct/2018, Accepted: 22/Nov/2018, Online: 31/Dec/2018

Abstract— In recent years, intensifying traditional agricultural practices act as an immediate strategy for increasing global food supply, but excessive use of agrochemicals cause pollution. Imbalanced nutrient management and decreased soil organic matter are the main factors responsible for yield decline. Nanotechnology is an innovative technology and has wide range of potential environmental and engineering applications like in agricultural systems, biomedicine, water resources, energy conversion and numerous other areas. It is working with the smallest possible particles which raise hopes for improving agricultural productivity through encountering problems unsolved conventionally. Advancement in materials science increased exponentially in the last decade and arriving in our days at a large variety of nanomaterials, which can deliver new environment technologies, due to their immensely powerful capacity. This article reviewed the potential uses of nanomaterials in sustainable agriculture with specific reference to soil remediation and environmental cleaning.

Keywords—Agro-ecosystem, Environment, Nanomaterial, Soil remediation

I. INTRODUCTION

Agricultural sector is the backbone of Indian rural economy and plays a significant role in the process of economic enlargement [1]. Approximately 60% of Indian population and 115.5 million people depend upon agriculture since independence [2, 3]. In recent years, intensifying traditional agricultural practices (like use of chemical fertilizer, pesticides and heavy irrigation) was practiced as an immediate strategy for increasing global food supply, but the excessive use of agrochemicals cause pollution of biosphere. Imbalanced nutrient management and decreased soil organic matter are the main factors responsible for yield decline. For improving soil organic matter status and increasing crop production, addition of crop residue, farmyard manure and green manure are widely recognized agricultural practices. Besides these, there is a new alternate option that is use of nanomaterials in agricultural field. Use of nanomaterials in agricultural industry is not only helpful in reduction of use of chemical fertilizer and pesticide, famine, hunger etc. but also in soil remediation. In the present article, we discuss the use of nanotechnology (nanomaterials) in field of sustainable agriculture with special emphasis on soil remediation and in environmental cleaning.

II. NANOTECHNOLOGY AND AGRICULTURE

Nanotechnology is the new growing field in the agriculture sector as it is one of the most important tools in the agricultural applications for plant and crop efficiency [4, 5]. They have multifunctional role in different fields such as water treatment, biomedical and drug delivery, metallurgy and materials, energy storage and agriculture and biotechnology (Fig. 1) [6-8]. Sometimes nanomaterials (carbon black-halloysite nanotube hybrid fillers) can also use in oil seal applications in rubber industry as it has superior properties among all fillers [9]. Modern agricultural practices have led to soil degradation due to soil erosion, soil acidity, alkalinity, loss of microbial activity etc. Nanotechnology can serve as major tool in remediating the negative consequences associated with soil health. Nanoparticles in agricultural field avoid excess use of chemicals such as fertilizers and pesticides that have negative impact on soil such as nutrient loss, soil infertility and leaching etc. and it increases produce efficiency and productivity through water and nutrient quality enhancer.

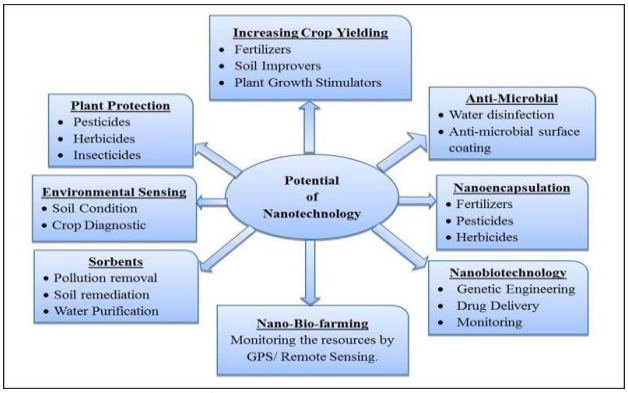

Figure 1: Application of nanomaterials in soil and agricultural sector [7].

Soil management is playing another important role in agriculture industries because soil serves as media for growth of all types of plants and tiny creatures. Soil forms essential elements in the ecosystem and provide habitat for animals and micro-organism that live in the soil. Top layer of soil is rich in organic matter. This layer is the best for growing crops and microbial activity. These top most soils are destroyed by soil erosion hence nanotechnology is the better option for the control of erosion such as soil binder (also called the soil set). Nanotechnology employed to avoid soil erosion (Sequoia Pacific Research of Utah, USA) and reduce the top soil loss of the different location.

Nanotechnology has provided new opportunities to advance nutrient use efficiency, nano fertilizer replaces the conventional fertilizer practices and improve the soil characteristics. It is helpful in absorption of nutrient to plant roots and microorganism and enhancing crop productivity. Plant growth-promoting rhizobacteria (PGPR) also acts as fertilizers by conventional method, they are effective in some cases, while nano encapsulation technology could be used as a method to protect PGPR and enhancing their retention time in soil micro flora and fauna. Nanomatrials are also helpful in immobilization of nutrients and reduction of leaching. It controls eutrophication by reducing the transfer of nitrogen and other chemicals to surface and ground water [10]. On the other hand, nanotechnology could helpful in structure and function of pesticides by improving solubility, enhancing resistance against photo catalysis and hydrolysis and by providing a more specific and controlled release against target pest [11, 12]. Nano-encapsulations for drug delivery are also important practices for control of pest and pathogen and improve crop productivity.

III. NANOTECHNOLOGY AND SOIL REMEDIATION

Nanotechnology offer new tools for agriculture and soil remediation. Nanoscale iron particles are very effective for the transformation and detoxification of a wide variety of common soil contaminants, such as chlorinated organic solvents, organochlorine pesticides, and polychlorinated biphenyls (PCBs). Nanoscale based zero-valent iron is most widely used nanomaterials that could remediating pollutants in soil. Other nanoparticles that could be used in remediation such as nanoscale zeolites, metal oxides, carbon nanotubes etc. Nanoparticle filters can be used to remove organic particles and pesticides (for example, dichloro-diphenyl-trichloroethane (DDT), endosulfan, malathion) from water. Application of nanoparticles (P, Zn, Mg) as nutrients may trigger enzymes and growth promoting substances to release through roots resulting influence on microbial population in the rhizosphere and nanosensors that can help in tracing particular microbial performance in the rhizosphere (Table 1). Nanotechnology is also useful in soil moisture capturing. Hydrogels, polymers, nano-clay and nano-zeolites have been reported to encouraging the water holding capacity of soil, hence more retention time and slow release of water during crop season and decrease water deficiency of the crop [13].

Nanotechnology raises hope for new innovation in the field of soil management and agricultural application. New research objective is to make plants use water, fertilizers, and pesticides more efficiently and reduce pollution and cost to make agro ecosystems eco-friendly. Nanotechnology is widely used in agriculture sector for productivity enhancement by nano-porous zeolites (for slow release and effective dosage of water and fertilizer) and nano-capsules (for herbicides introduction and pest management). Application of nanotechnology also encourages the quality of food for consumers that are rich in micro and macro nutrients. Some nanotechnology practices are also applicable at commercial level such as nanosensor and nanoscale coating that replace the thicker more waste polymer coating and prevent corrosion.

IV. NANOTECHNOLOGY AND ENVIRONMENT

Nanotechnology, is not only useful in agriculture and soil remediation but it is also helpful in detecting environmental problems and act as effective tool for solving air, water and soil pollution [11, 14,15]. Nanoparticles are useful in detection, purification and monitoring of environmental resources. Nanotechnology are also helpful to nano bio-farming by using of GPS/ remote sensing for landscape monitoring of soil as well as the agricultural resources like soil quality, moisture, detection of disease, crop health and ground water etc. and also sense the drought and famine for the critical conditions [16]. These are useful for the detectation of the toxicity of aquatic organisms. Nanoscale polymers are used for decrease contamination and recycling of heavy metals and hazardous organic materials using of nanostructured material.

Table 1: Applications of nanotechnology in agriculture

Areas	Nanomaterials and their uses	Appliccations
Soil & Water management	Nanomaterials such as nano-clay, hydrogel,zeolites, filtering & binding to toxicants	Filter-membrane with TiO_2 nanoparticles for hydrolysis& photo-catalysis degradation of agrochemicals
Plant Protection products	Nanoparticles, nanosensor, smart delivery systems	Improve the crop productivity & enhance the practices of sustainable agriculture
Anti-microbial	Nanoparticles & nano-capsules are effective drug delivery against bacteria	Zinc oxide & MgO are useful to the check of harmful bacterial growth

Fertilizers	Nano-capsules, nanoparticles for the enhancement of nutrients	Macronutrients fertilizers with ZnO coated nanoparticles, enhance the soil fertility
Remediation	Nanoscale particles a tool to remediate of soil & water contaminants	Nanoparticles like Fe, Zn, and Mg etc. are also act as a detoxificant to the number of chemicals
Control soil erosion	Nano-zeolite, nano-clay& nano-binder are checking the soil erosion	Nano-zeolites are act as fiber like structure & form a chelate like structure
Plastic Technology	Nano-composite bioplastic & nano-polymer, they are thermoformed plastic	Biodegradable after use, made renewable & sustainable resources (non GM corn starch)
Disease detection	Nano-sensors, carbon nanotubes & smart delivery system	Use of nano-sensors for detection of plant disease, monitoring soil condition and plant growth
Public health	Nanoparticles, nano-pesticides & nano-sensors etc	For control of number of disease such as malaria, filarial, dengue & cholera etc.
Recycling of agricultural wastes	Nanofiber, nanosensor& nanoparticles	Fibers can be used as chemicals& pesticides absorbent & convert agricultural waste to useful products & reduce waste size
Other than agriculture & public health	Nano particles & nano-pesticides	Control of vegetation in forests & factory sites by using fumigants

V. CONCLUSION AND FUTURE SCOPE

Nanotechnology is effective tools for soil management and agricultural production and also in remediation of environment. It is also known as green nanotechnology or clean technology because it has capacity to reduce environmental pollution and human health risk by utilization of nano-technological products.

ACKNOWLEDGMENT

We thank the Head and the course Co-ordinator, Institute of Environment and Sustainable Development, BHU, for providing facilities for dissertation. This work is the part of dissertation. We are also thankful to Gyanpur Degree College for allowing collaborative research.

REFERENCES

[1] A. Naiyer, U.I. Sarfraz and Md. U.l Haque, *"Agriculture Play Crucial Role in the Life of Indian Economy"*, Int. J. Sci. Res. Manag., Vol. 3, Issue 3, pp. 2239-2245, 2015.

[2] M.A. Kekane, *"Indian Agriculture-Status, Importance and Role in Indian Economy"*, Int. J. Agric. Food Sci. Tech., Vol. 4, Issue 4, pp. 343-346, 2013.

[3] G. Pandey, *"Challenges and Future Prospects of Agri-Nanotechnology for Sustainable Agriculture in India"*, Env. Tech. & Innov., Vol. 11, 299-307, 2018.

[4] P. Wang, E. Lombi, F.J. Zhao and P.M. Kopittke, *"Nanotechnology: A New Opportunity in Plant Sciences"*, Trends Plant Sci. , Vol. 21, pp.699-712, 2016.

[5] L. R. Khot , S. Sankaran , J. M. Maja, R. Ehsani , and E.W. Schuster,*"Applications of Nanomaterials in Agricultural Production and Crop Protection: A Review"*, Crop Protection, Vol. 35, pp.64-70,2012.

[6] S. Deva and L. Kadiri, *"A Review on Impact of Nanoparticles on Plant Growth and Development"* Adv. Life Sci., Vol. 5, Issue 1, pp. 16-21, 2016.

[7] O. Zaytseva and G. Neumann, *"Carbon Nanomaterials: Production, Impact on Plant Development, Agricultural and Environmental Applications"*, Chem. Bio. Tech. Agric., Vol. 3, Issue 17, pp.11-26, 2016.

[8] T. Dhewa, *"Nanotechnology Applications in Agriculture: An Update"*, Octa J. Env. Res., Vol. 3, Issue 2, pp.204-211, 2015.

[9] B. Prabu1 and K. Senthilvel, "*Studies on the Mechanical Properties of Carbon Black-Halloysite Nanotube Hybrid Fillers in Nitrile /PVC Nanocomposites for Oil Seal pplications*", Int. J Scientific Res Physics Appl Sci., Vol. 6, Issue.4, pp.63-68, 2018.

[10] R. Liu, and R. Lal, *"Potentials of Engineered Nanoparticles as Fertilizers for Increasing Agronomic Productions"*, Sci. Total Env., Vol. 514, pp.131-139,2015.

[11] P. Biswas and C.Y. Wu, *"Critical Review: Nanoparticles and the Environment"*, J. Air Waste Manag. Assoc., Vol. 55, pp.708-746, 2005.

[12] R. Grillo, P.C. Abhilash and L.E.Fraceto, *"Nanotechnology Applied to Bioencapsulation of Pesticides"*, J. Nanosci. Nanotech., Vol. 16 , pp.1231-1234, 2016.

[13] B.S. Sekhon, *" Nanotechnology in Agrifood Poduction: An Overview"*, Nanotech. Sci. Appl., Vol. 7, pp. 31-53, 2014.

[14] M. I. Litter, W. Choi, D. Dionysiou, P.F.A. Hiskia, G. Li Puma, and J. Zhao, *"Nanotechnologies for the Treatment of Water, Air and Soil*", J. Hazard. Mat., Vol. 211-212, pp.1-2, 2012.

[15] D. Rawtani, N. Khatri, S. Tyagi and G. Pandey, *"Nanotechnology-Based Recent Approaches for Sensing and Remediation of Pesticides"*, J. Env. Manag., Vol. 206, pp. 749-762, 2018.

[16] A. Singh, *"Managing the Water Resources Problems of Irrigated Agriculture through Geospatial Techniques: An Overview*", Agri. Water Manag., Vol.174, pp.2-10, 2016.

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