International Journal of Environmental Engineering and Management.
ISSN 2231-1319, Volume 4, Number 3 (2013), pp. 161-164

http://www.ripublication.com/ ijeem.htm

Sustainability Issues of Discharging Engineered Nanomaterials in Wastewater

S. Srivastava[1], A. Godara[2], P. Das[3], and A. Kumar[*,4]

[1]*Department of Civil Engineering, Indian Institute of Technology HauzKhas, New Delhi, INDIA.*
[2]*Department of Civil Engineering, Indian Institute of Technology HauzKhas, New Delhi, INDIA.*
[3]*Department of Civil Engineering, Indian Institute of Technology HauzKhas, New Delhi, INDIA.*
[4]*Department of Civil Engineering, Indian Institute of Technology HauzKhas, New Delhi, INDIA.*

Abstract

Recently, studies have reported occurrence of engineered nanomaterials (ENMs) in wastewater treatment plants (WWTP) where bacteria interact with ENMs. Due to toxic nature of ENMs, they kill bacteria in biological processes and affect biological activity. It raises the important question whether continuous exposure of ENMs to bacteria induces some changes in bacteria which might disrupt biological activity during continuous exposures of bacteria in wastewater treatment plant. This question is important to answer to know sustainability aspect of discharging ENMs-based products in wastewater, which subsequently is disposed in the environment. This study aimed to understand this aspect by reviewing toxicity data of metal-based ENMs on bacteria and analyzing findings to understand possible long-term effects of bacteria interaction with ENMs in wastewater treatment plant. Findings of this review work indicated that although information about short-term exposure of bacteria to ENMs is available in laboratory conditions, this information is lacking on continuous exposures of bacteria to ENMs.

Keywords: Engineered nanomaterials; sludge; sustainability.

1. Introduction

Recently, studies have reported occurrence of engineered nanomaterials (ENMs) in wastewater treatment plants (WWTP) where bacteria interact with ENMs (Kiser et al., 2009). Due to toxic nature of Ends, they kill bacteria in biological processes and might affect biological activity. It raises the important question whether continuous exposure of Ends to bacteria in wastewater induces some changes in them, which might disrupt their biological activity over long periods. To date, very few studies have focused on bacteria-ENMs interaction with regards to sustainability issue of discharge. The objective of this study was to understand implications of continuous exposure of ENMs to bacteria on their biological activity and on ENMs concentrations in wastewater effluent and in sludge and understand sustainability issues.

2. Methodology

First sustainability criteria with regards to discharge of ENMs in wastewater were identified. Secondly, published reports and journal papers were reviewed to first evaluate current practice on identified criteria. Thirdly, knowledge gaps in achieving sustainability during ENMs discharge in wastewater were identified.

3. Results and Discussion

To investigate sustainability of ENMs discharge in wastewater, following criteria were identified: (1) Fate of ENMs in WWTP and (2) Effect on biological activity of microorganisms. Table 1 presents listing of ENMs-based studies in wastewater treatment plants. Most of these studies have attempted to understand fate of ENMs in WWTP; however, detailed description of mechanisms of removal of ENMs in WWTP is not available for all types of ENMs. After WWTP, these ENMs reach river bodies or soil, where they could be toxic to ecosystems and human beings, which need to be studied in detail as function of treatment plant removal effectiveness. The toxic effects of ENMs to bacteria have been known. But when ENMs come in contact with bacteria in environment, there bioavailability and toxicity to bacteria is not desirable as it inhibits microbes, which perform many critical roles required for normal ecosystem functioning. Table 1 also provides summary of studies focusing on toxicity of ENMs to microorganisms. Most of these studies focused on effect of ENMs presence on oxygen consumption rate, nitrification rate, and methane formation potential of microorganisms. These studies have reported some effects on biological parameters during short-term exposure; however, detailed studies focusing on long-term exposure of ENMs to microorganisms are required.

Table 1: Listing of ENMs-based studies in wastewater treatment plant with different focuses.

Reference	**Nanoparticles**	**Study focus**
Fate studies		
Chang *et al.* (2007)	SiO_2 NPs	Removal of NPs from a coagulation unit using polyaluminum chloride
Limbach *et al.* (2008)	CeO_2 NP	Removal of CeO_2 NP from wastewater clearing sludge
Jarvie *et al.*(2009)	SiO_2	Study of effect of surface functional groups on SiO_2 fate in wastewater treatment plant
Ganesh *et al.*(2010)	Cu NPs, ions	Evaluation of nanocopper removal and toxicity in municipal wastewaters
Johnson *et al.* (2011)	TiO_2 NP	removal of TiO_2 in wastewater treatment plant
Westerhoff *et al.* (2011)	TiO_2 NP	removal of TiO2 in wastewater treatment plant
Toxicity studies		
Choi and Hu (2008)	Ag NPs (9 – 21 nm)	*Exposure to aerobic Nitrifying Bacteria*
Liang *et al*. (2010)	Synthesized Ag NPs	*Exposure to Aerobic Nitrifying Bacteria*

4. Summary and Conclusions

This study assessed current status of sustainability of ENMs discharge in wastewater using following criteria: (1) Fate of ENMs in WWTP and (2) Effect on biological activity of microorganisms. Although some studies were found giving this information, more efforts are required to (1) obtain data for all ENMs, (2) assess sustainability aspect as a whole including WWTP and future disposal options. Overall, above mentioned issues are important to consider given increased used of ENMs in consumer products and their subsequent uncontrolled discharge in environment and indicate the need for formation of laws, policies and safety measures regarding ENMs disposal in WWTP and in environment.

5. Acknowledgements

Authors would like to acknowledge IIT Delhi (India) and Department of Science and Technology (India) for supporting this study.

References

[1] A C Johnson, M J Bowes, A Crossley, H P Jarvie, *et al.* (2011), An assessment of the fate, behaviour and environmental risk associated with sunscreen TiO_2 nanoparticles in UK field scenarios, *Sci. Tot. Environ.,* **409,** pp. 2503-2501.

[2] H P Jarvie, H Al-Obaidi, S M King, et al. (2009), Fate of silica nanoparticles in simulated primary wastewater treatment, *Environ. Sci. Technol.,* **43**, pp. 8622-8628.

[3] L K Limbach, R Bereiter, E Muller, R Krebs, R Galli, and W J Stark (2008), Removal of oxide nanoparticles in a model wastewater treatment plant: Influence of agglomeration and surfactants on clearing efficiency, *Environ. Sci. Technol.,* **42**, pp. 5828-5823.

[4] M A Kiser, P Westerhoff, T Benn, Y Wang, J Pe´rez-Rivera and K Hristovski (2009), Titanium nanomaterial removal and release from wastewater treatment plants, *Environ. Sci. Technol.,* **43** (17), pp. 6757–6763.

[5] M R Chang, D J Lee, J Y Lai (2007), Nanoparticles in wastewater from a science-based industrial park-Coagulation using polyaluminum chloride, *J.Environ. Mgmt.,* **85,** pp. 1009-1014.

[6] P Westerhoff, G Song, K Hristovski, and M A Kiser (2011), Occurrence and removal of titanium at full-scale wastewater treatment plants: Implications for TiO_2 nanomaterials, *J. Environ. Monit.,* **13,** pp. 1195-1203.

[7] O Choi and Z Hu (2008), Size dependent and reactive oxygen species related nanosilver toxicity to nitrifying bacteria, *Environ. Sci. Technol.,* **42**(12), pp. 4583-4588.

[8] R Ganesh, J Smeraldi, T Hosseini, L Khatib, B H Olson, and D Rosso (2010), Evaluation of nanocopper removal and toxicity in municipal wastewaters, *Environ. Sci. Technol.,* **44**, pp. 7808-7813.

[9] Z Liang, A Das, and Z Hu (2010), Bacterial response to a shock load of nanosilver in an activated sludge treatment system, *Wat. Res.,* **44** , pp. 5432-5438.