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Aquatic environmental monitoring and removal efficiency of detergents

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Abstract

In this study, the detergent's concentrations in aquatic environment principally drinking and surface water along River Nile and near rural village were determined to report the influence of different physicochemical characteristics on the distribution of linear alkylbenzene sulfonate (LAS) that lead to toxicity in human beings. The removal efficiency of LAS using zeolite and granular activated carbon technique was assessed.

The results showed wide variations observed between surface (0.07–0.38 mg LAS/l) and bottom water (0.05–0.17 mg LAS/l) due to increase in population density and human activities that recorded highest concentration along rural area (surface: 1.24–2.45 and bottom: 0.93–1.083 mg LAS/l). Low concentration of surfactants was found in drinking water (0.005–0.007 mg LAS/l) compared to the concentration of the corresponding water samples along the River Nile. In conclusion, the study indicated that the treatment processes for drinking water production were insufficient for the complete removal of surfactants and adsorption process by using zeolite as low cost, most beneficial, economically feasible method as well as easy to operate for producing high quality of water.

Keywords: Detergent; Water quality; River Nile; Drinking water; Treatment

1. Introduction

Environmental studies reported that the problem of detergents is growing rapidly in developing countries and rural communities (Feisthauer et al., 2004). It is noted that inappropriate and less efficient water purification process led to presence of surfactants in the finished water due to their physicochemical properties (high water solubility and often poor degradability) which allow them to penetrate through all natural filtration steps and man-made treatments, thus presenting a potential risk in drinking water supply (Norfazrin et al., 2012).

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Detergents are compounds derived from synthetic organic chemicals (mainly surfactant) that have cleaning power. These compounds generally xenobiotic compounds contain a polar head group (soluble in water – hydrophilic) and non-polar hydro carbonate tail (insoluble in water – hydrophobic) properties in one molecule (Ying, 2006). Surfactants are classified as anionic, cationic and non-anionic and amphoteric by their ionic activity (special nature) in water (Dehghani et al., 2007). LAS (linear alkylbenzene) is mainly a group of anionic surfactant (Shafqat et al., 2012) that is found in drinking water (Makwana et al., 2012), as well as in domestic and industrial wastewaters in extended volume than any other groups because of their ease and low cost of manufacture (Salvato et al., 2003).

Pattusamy et al. (2013) have recently reported that detergents must be prevented from entering in channels to avoid eutrophication of aquatic environments, because detergents prevent the growth of microorganisms that are pathogenic species in nature with higher loads in river. The surfactants are also responsible not only for causing foam in rivers and creating procedural problem during wastewater treatment and but also for reduction of water quality (Vinod et al., 2012). Environmental studies reported that it must be elucidated and assessed the potential health hazards of detergents on aquatic life form which hampers water quality (Adewoye, 2010; Udiba et al., 2013). This phenomenon will eventually promote negative impacts toward human health that leads to blood toxicity, as well as eye and skin irritation (Fujii et al., 2007). LAS has toxic impact on aquatic faunas, floras in soil, preventing soil from re-depositing and as a result, causing environmental problems for cultivated vegetables (Ghoochani et al., 2011). It can also induce severe damage to vital organs, even hematological, hormonal and enzyme disturbances (Ogundiran et al., 2009), growth and development of the plankton constituents (Mukherjee et al., 2010), as well as toxic to aquatic life at $\leq$0.025 LAS/l. LAS has adverse effects on aquatic species at 0.005 LAS/l (Misra et al., 1987) and may cause histological degradation in fish species (Fujii et al., 2007).

Detergents play an important role toward increasing pollution originated from wastewater that comes from residential areas in the form of household detergent, agriculture runoff in the form of herbicides and insecticides and from certain industries (Vinod et al., 2012). About 90–97% of the detergents can be biodegraded by bacteria and can get decomposed in small quantities in anaerobic conditions (Yangxin et al., 2008). Biotechnology techniques recently have described an important group of bio-surfactants using lipases or enzymes that can reduce environmental load of detergent products as the chemicals used in conventional methods; they are biodegradable and non-toxic, and also leave no harmful residues (Fariha et al., 2010).

Water for human consumption must be free of microorganisms and chemical substances in concentrations large enough to cause environmental imbalance and disease (Aremu et al., 2011; Shivaraju, 2012).

Thus, determination of surfactants, in river water as raw water supply, drinking and treated water, is important since surfactants have become a threat to our water supply network. Many researchers have shown that activated carbon is an effective adsorbent for treating water with high concentrations of organic compounds (Syafalni et al., 2012b). Its usefulness is derived mainly from its large micropore and mesopore volumes and the resulting high surface area (Fu and Wang, 2011). Low cost adsorbent such as zeolite nowadays has been explored for its ability in many fields especially in water treatment. Natural zeolite has negative surface charge which gives advantages in absorbing unwanted positive ions in water such as heavy metals; these ions can move within the large cavities allowing ionic exchange and reversible re-hydration (Jamil et al., 2010), and adsorbent surfaces are particularly useful for altering the surface charge from negative to positive with surfactant in order to achieve higher performance in removing organic matter (Chao and Chen, 2012).

This study aimed to analyze the concentration of detergent in surface and bottom water of River Nile used for drinking water. The influence of physical–chemical measurements on the distribution of detergent load was also being investigated because its bioaccumulation can lead to toxicity in the human beings. In addition, the current ability of water treatment processes toward the removal of detergent was examined and the performance of removal of LAS from aquatic environment by means of zeolite and granular activated carbon was assessed.

2. Materials and methods

The present work investigated water characterization for four sites along River Nile ecosystem during summer 2013. In situ measurements, chemical (inorganic and organic) pollutants and bacteriology measurements were analyzed for 16 environmental samples according to (Eaton et al., 2005) methods. The data were compared with water quality standards (Egyptian Environmental Law 48 – Decision 92/2013, WHO, 2006 and European Community, 1989).