Ecotoxicology and Environmental Safety ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

LAS degradability by marine biofilms derived from seawater in Spain and Sweden

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ARTICLE INFO

Article history:
Received 16 May 2010
Received in revised form
18 February 2011
Accepted 19 February 2011

Keywords:
Biofilm
Acclimation
Temperature
Marine
Biodegradation
LAS

ABSTRACT

Marine biofilms were established on glass beads with or without deliberate pre-exposure to LAS (20 μg/L) in Spain (Cadiz) and Sweden (Kristineberg). The ability of each community to mineralize LAS (100 μg/L) was then assessed in biometers at four experimental temperatures (between 6 and 21 °C). Genetic diversity and biomass of the biofilms were assessed by genetic fingerprinting (DGGE) and direct bacterial counts. With biofilms from Sweden, where LAS was not detected in seawater ($n=3$), deliberate pre-exposure to LAS resulted in lower genetic diversity and higher mineralization rate constant; however, with biofilms from Spain, where 6.4 ± 3.9 μgLAS/L ($n=3$) was measured during the colonization, pre-exposure did not affect the bacterial community. Bacterial acclimation therefore appeared to have been induced at environmental concentrations <6 μgLAS/L. Environmental pre-exposure was not a pre-requisite for featuring the full consortia of LAS degraders in the biometers. The mineralization rate was described using an Arrhenius equation at experimental temperatures within the typical annual range; however, they departed from this model below this range.

1. Introduction

Linear Alkylbenzene Sulfonate (LAS) is a synthetic surfactant commonly used in detergents. Some 340 kilotons of this high production volume (HPV) chemical were consumed in Europe in 2005 (HERA, 2007). Growth of LAS usage worldwide is expected to average about 1.7% per year during 2008–2013 (Modler et al., 2009). Because it is removed very efficiently in waste water treatment plants (León et al., 2006), and subsequently in river waters (Takada et al., 1994; McAvoy et al., 2003; Whelan et al., 2007), LAS concentrations in estuarine and coastal waters are typically below 50 μg/L where sewage treatment systems are installed (Matthijs and Stalmans, 1993; Gonzalez-Mazo et al., 1998; Lara-Martín et al., 2008). Higher concentrations, up to 2500 μg/L, have been detected in coastal waters close to untreated discharge outlets (Gonzalez-Mazo et al., 1998). Temara et al. (2001) reported a predicted no-effect-concentration (PNEC) of 31 μgLAS/L for marine pelagic communities.

Marine biodegradation is typically assessed in closed test systems using water, with or without sediment, as an inoculum, according to OECD 306 recommendations (1992). The lifetime of a closed biodegradation unit will end when the degrader community loses its viability. This will eventually occur due to unfavorable growth conditions such as predation (grazing), and depletion of: (1) the volume of the water sample; (2) essential nutrients; or (3) primary carbon substrates (Painter, 1995; Torang and Nyholm, 2005). Therefore, the duration of the lag phase prior to biodegradation must be shorter than the system lifetime to allow detection of the potential activity of the microbial community, and thus to avoid false negative outcomes. To mitigate the problems of poorly reproducible biodegradation lag phases, two approaches have been considered: the use of inocula deliberately pre-exposed to the test compound or the use of biodegradation units with high biomass. Regulatory authorities have generally disliked the use of pre-exposed inocula in screening tests (Torang and Nyholm, 2005). Their concern is the creation of "superbugs" or unnaturally "over-adapted" inocula. On the other hand, using a high biomass in the test units has the advantage of increasing the probability that the bacterial community added gets acclimated to the compound within the test lifetime. In fact, since there can be no immigration into a closed system, system lifetimes are likely to be highly dependent on the initial biomass. The recently developed biofilm approach is based on using biofilms colonized on glass beads. This approach uses a convenient system with a high biomass, that is approximately three orders of magnitude larger than in a similar volume of seawater (Mauffret et al., 2009).

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doi:10.1016/j.ecoenv.2011.02.016

Please cite this article as: Mauffret, A., et al., LAS degradability by marine biofilms derived from seawater in Spain and Sweden. Ecotoxicol. Environ. Saf. (2011), doi:10.1016/j.ecoenv.2011.02.016