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LAS BIODEGRADATION AND REMOVAL IN ONSITE WASTEWATER TREATMENT

In many parts of the world, municipal wastewater treatment facilities are not readily available and wastewater from households is discharged to septic tanks (onsite systems) for treatment. In the U.S., about 20-25 percent of the households, usually at rural locations, utilize onsite treatment of household wastes.(1) Septic systems are also used in major cities in Southeast Asia.(2) These onsite wastewater treatment facilities are regulated by local governments. In the U.S., the Environmental Protection Agency (EPA) provides guidance and technical assistance to help develop and enhance onsite programs. When properly operated, septic tank treatment of onsite waste is a cost-effective, hygienic method of wastewater treatment.

A study by Cornell University(3) indicated that the average U.S. household generates 55 to 75 gallons of waste water per person per day. Sources include toilets, showers, sinks, dishwashers, and washing machines. The diversity of sources means that household wastewater contains a variety of biological and chemical constituents found in sewage, food waste, and assorted household products that are washed or poured down the drain. A typical septic tank may contain more than 100 traceable chemical components, including surfactants (including linear alkylbenzene sulfonate, LAS) contained in laundry and cleaning products.

When LAS was commercially introduced in the early 1960s as a replacement for highly branched alkylbenzene sulfonate (ABS), studies were already being reported on the biodegradation behavior of LAS compared to ABS under septic tank conditions. Results from laboratory benchscale septic tank and drain field studies indicated that LAS was 90 to 95 percent biologically degraded compared to about 35 percent for highly branched ABS under similar conditions.(4) Over the years, several detailed studies, including studies conducted in the field using established septic tank fields and aquifers which indicated that LAS is rapidly biodegraded and mineralized and completely removed in onsite treatment systems such as septic tanks.(5,6,7,8,9) Key points from these studies are summarized below.

- Relative to effluents from municipal wastewater treatment systems, effluents from onsite systems may contain higher concentrations of LAS and other detergent chemicals. Research has shown that subsurface environments contain significant quantities of heterotrophic microorganisms which are capable of biodegrading a range of detergent chemicals, including LAS.(7)

- The rate and extent of LAS biodegradation was generally unaffected by soil type. Complete biodegradation or mineralization was measured by the use of LAS radiolabeled in the benzene ring with carbon-14 (^{14}C) as biodegradation of the ring carbon to carbon dioxide (CO_2) and cell biomass is known to represent the last steps in LAS biodegradation. Use of ^{14}C ring-labeled LAS indicated cumulative values for $^{14}CO_2$ production reached high values (60 to 70%), indicating essentially complete biodegradation of LAS as the remaining amount of radiolabel is expected to be incorporated into cell biomass of the biodegrading organisms. Furthermore the amount of biodegradation was consistent across the range of soils (seven types) tested, indicating that the soil type had little effect on biodegradation. Degradation proceeded without a noticeable lag phase, indicating that soil microbial communities were already adapted to the biodegradation of LAS.(7)

- Biodegradation half-lives (the time required for half the substance to degrade) for LAS were relatively constant and showed little variation as a function of soil type both in mesocosm and field studies. Half-life values ranged from about 1 to 5 days, averaging about 2 days in the majority of samples tested. The half-lives measured for LAS in these studies were comparable to values measured for a naturally occurring fatty acid (stearic acid) and in the range of values reported for LAS biodegradation in the literature.(7)

- Biodegradation of LAS was also assessed in an established septic tank system and an adjoining shallow sand aquifer located near Cambridge, Ontario.(8) Studies were conducted on soil, aquifer sediment and groundwater samples from a transect of the septic tank effluent plume. LAS was rapidly biodegraded in the vicinity of the discharge, with mineralization half-lives in soil and sediment samples collected near the tile field ranging from 9 to 17 days. Similar results were obtained for ground water. Adaptation was a key process in the system, as illustrated by the rapid biodegradation near the tile field and limited biodegradation at locations far downgradient or upgradient of the system, where little or no LAS. The results demonstrate that properly functioning septic tank systems can effectively remove LAS.

- A study in aimed at determining the sorptive and biodegradable characteristics of LAS using soil obtained below a Florida septic system drainfield has been carried out.(9) Three distinct soil samples were collected from the septic system drainfield and used in laboratory sorption and biodegradation studies. Different LAS concentrations were added (in ^{14}C radiolabeled and unlabeled forms) to a series of test vessels that contained upgradient groundwater and the soils collected from the study site. The sorption test was designed to determine the partitioning of LAS between groundwater and soil in each sample. Results indicated that the sorption distribution coefficient (K_d) decreased from 4.02 to 0.43 L/kg and that the rate of ultimate biodegradation (1st-order rate constant k_l) decreased from 2.17 to 0.08/day with increasing distance (0.7-1.2 m vertically below ground surface and 0 to 6.1 m horizontally) from the drainfield. The 3 soils showed 49.8-83.4% LAS mineralization (percentage of theoretical CO_2) over 45- or 59-day test periods. These results demonstrate that subsurface soils in this system have the potential to sorb and biodegrade LAS.

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