


**ECOTOXICITY ELEMENTS**  
**TOXICITY TO SEDIMENT ORGANISMS**  
**Freshwater benthic organisms, laboratory ecotoxicity study**

**PAPER REVIEWED**

Pittinger, C.A., Woltering, D.M., Masters, J.A. 1989. Bioavailability of sediment-sorbed and aqueous surfactants to *Chironomus riparius* (midge). Environmental Toxicology and Chemistry, 8, 1023-1033.

**TEST SUBSTANCE**

- Unlabelled (C<sub>11.8</sub>) LAS (supplier not mentioned): commercial formulation with an activity of 30.4 % (determined by desulfonation-GC) and molecular weight of 346 g/mol.
- Radiolabelled <sup>14</sup>C-LAS (New England Nuclear, Boston, U.S.): <sup>14</sup>C on the α-carbon of the dodecyl chain, specific activity of 8.99 mCi/mmol, purity > 99 % (determined by TLC and GC).

 Remarks: LAS concentrations are expressed on the basis of the weight of the active ingredient. Unlabelled and labelled LAS were combined in known proportions in aqueous stock solutions to provide sufficient radioactivity in sediment and water samples for liquid scintillation counting (LSC).

**METHOD**

- Laboratory Procter & Gamble Ivorydale Technical Center, Cincinnati, Ohio
- Objectives To assess the relationship between sediment/water partitioning and bioavailability of LAS to the freshwater midge *Chironimus riparius*.  
Additional objectives not reviewed in this summary: assessment of the surfactants dodecyl trimethyl ammonium chloride (TMAC) and distearyl dimethyl ammonium chloride (DSDMAC).
- Method/guideline followed Methods fully described in reviewed paper. Briefly, 1 acute egg hatchability assay, 2 chronic midge larval and pupal development assays and 2 chronic assays to assess effects of substrate type upon LAS bioavailability were conducted.
  - Egg hatchability, posthatch survival procedure (static-renewal tests): intact egg loops of *C. riparius* were transferred to a test chamber which was suspended in a beaker containing LAS solution. Duplicate chambers were prepared for each of 5 test concentrations and control. Test solutions were

replenished daily. Tests were continued for 72 h posthatch. Numbers of larvae and unhatched eggs were recorded daily.

- Chronic midge larval and pupal development test procedure (flow-through tests): 20 larvae (72 h posthatch) were randomly distributed to each test chamber (5 duplicated test concentrations + control). Tests were continued until all live midges emerged as adults (24 days on average). Numbers of winged adults were recorded daily.
  - In the initial chronic assay, effects of solubilized LAS to the midge were compared between chambers containing no sediment and chambers containing natural, unspiked stream sediments.
  - The second chronic assay exposed organisms to a range of LAS concentrations in prespiked sediment. Based on the NOEC observed in the initial chronic assay, a single subchronic LAS concentration (< 0.5 mg/L) was replenished to the overlying water (OW) to minimize desorption of LAS from the sediment to the OW and simulate typical conditions of exposure.
- Chronic bioavailability test procedure: at each LAS concentration, 3 nonspiked substrate types (a pure sand substrate, a silt-sand (1:1) substrate and a silt substrate) in different chambers were simultaneously tested against a 4<sup>th</sup> chamber containing no substrate.

- Test substrate/application

Natural stream sediments (71 % clay, 19 % fine silt and 4 % medium and 6 % fine sands) were collected from a pristine site in Rapid Creek, South Dakota and contained no detectable levels of LAS. Description of the sediment characteristics in the reviewed paper. Before testing, wet sediment was autoclaved for 40-60 min to reduce microbial populations and minimize initial rates of surfactant biodegradation.

LAS was added to a sediment slurry at a nominal concentration and stirred overnight. Sediment was poured into each test chamber, allowed to settle and sampled for analytical monitoring. No further details on sediment spiking in the reviewed paper. Flow-through diluter systems delivered test materials in water.

- GLP

Likely not.

- Year (study performed)

≤ 1988

- Species/strain/supplier

*C. riparius* were laboratory reared at 22 °C in tanks with aerated well water and natural stream sediment. Supplier or collection site not mentioned.

- Analytical monitoring
 

LAS levels in sediments, overlying water and interstitial water were determined by LSC. Details on the sampling procedures, sample treatments and measurements in the reviewed paper.

OW and IW samples were collected every 2 to 3 days throughout the tests. Sediment-sorbed levels of LAS were measured at the beginning, twice during and upon completion of the sediment tests.
- Exposure period
  - Egg hatchability, posthatch survival tests: 72 h posthatch
  - Chronic tests: until all live midges emerged as adults (24 days on average).
- Endpoints
  - Egg hatchability, posthatch survival.
  - Chronic tests: % of winged adults emerging.
- Statistical methods
 

Chi-square analyses were used to detect significant differences among treatments and variance homogeneity. Probit analyses were used to calculate EC<sub>50</sub> values.

 Remarks: /

## RESULTS

- Nominal concentrations
  - Egg hatchability, posthatch survival tests: N.A.
  - Chronic midge larval and pupal development tests: N.A.
  - Chronic bioavailability tests: 0, 1.5, 3, 6, 12 mg LAS / L OW.
- Measured concentrations
  - Egg hatchability, posthatch survival tests: 0, 1.0, 4.7, 9.4 and 18.9 mg LAS / L.
  - Chronic midge larval and pupal development tests:
    - Initial chronic assay (concentrations deduced from figure in reviewed paper):
      - exposure without sediment: 0, 2.4, 3.7 and 6.1 mg LAS / L OW.
      - exposure with sediment: 0, 0.6, 1.1, 2.6, 4.5 and 9.5 mg LAS/ L OW.
    - Second chronic assay: See Table 1. LAS concentrations were also monitored in sediment and water compartments before (25 days) and during (21 days) a chronic assay under NOEC conditions. IW concentrations decreased most rapidly during equilibration period (days 1-25).

Variation in sediment LAS concentrations measured throughout the experiment was relatively high and no clear trend was observed.

- Chronic bioavailability tests: N.A.

- NOEC, LOEC, EC<sub>50</sub>

See Table 2.

Table 1: Partitioning of LAS in sediment and water compartments (mean values ± SE).

LAS in sediment (mg/kg)	LAS in IW (mg/L)	LAS in OW (mg/L)
993 ± 225	15.2 ± 2.7	1.69 ± 0.12
319 ± 23	15.0 ± 1.4	1.05 ± 0.07
146 ± 18	7.7 ± 1.1	0.59 ± 0.05
42 ± 5	1.5 ± 0.3	0.35 ± 0.01
8 ± 2	0.2 ± 0.0	0.32 ± 0.01
0 (control)	0	0

Sediment and IW concentrations were measured at the completion of the tests.

Table 2: EC<sub>50</sub>, NOEC and LOEC values for LAS toward *C. riparius*.

Effect	Exposure route	Exposure time	EC <sub>50</sub>	NOEC	LOEC
Egg hatchability	water	until hatching (not specified)	N.A.	≥ 18.9 mg / L	> 18.9 mg / L
Posthatch survival	water	72 h posthatch	between 1.0 & 4.7 mg / L	1.0 mg / L	4.7 mg / L
Adult emergence	water	~ 24 days	N.A.	2.4 mg / L	3.72 mg/L
	water with unspiked sediment	~ 24 days	N.A.	N.A.	N.A.
	water with spiked sediment	~ 24 days	N.A.	319 ± 23 mg / kg sediment	993 ± 225 mg / kg sediment
				15.0 ± 1.4 mg / L IW	15.2 ± 2.7 mg / L IW
				1.05 ± 0.07 mg / L OW	1.69 ± 0.12 mg / L OW
	water	~ 24 days	N.A.	3 mg LAS / L OW	6 mg LAS / L OW
	water with sand substrate	~ 24 days	N.A.	6 mg LAS / L OW	12 mg LAS / L OW
	water with sand-silt substrate	~ 24 days	N.A.	3 mg LAS / L OW	6 mg LAS / L OW
water with silt substrate	~ 24 days	N.A.	6 mg LAS / L OW	12 mg LAS / L OW	

N.A. = Not available.

Remarks: ○ The presence of unspiked sediment during aqueous exposures reduced the

bioavailability of LAS relative to effects observed in exposures without sediment. NOEC and LOEC values for exposure with unspiked sediment, however, were not specified in the reviewed paper.

- It is not specified whether LAS concentrations in the sediment are given in mg / kg dry weight or mg / kg wet weight.
- No significant effects among different substrate types were detected. At a nominal concentration of 6 mg LAS / L, however, higher % of midge emergence were observed with each substrate than without substrate present.

## CONCLUSIONS

Chronic toxicity of LAS to *C. riparius* can be mitigated in the presence of high concentrations of sediments. The process by which sediments reduce LAS availability is not quantitatively understood.

In the reviewed paper, it was not clear that IW was the exposure route common for LAS to *C. riparius* (as suggested in other studies with congener species *C. tentans* and *C. decorus*). Moreover, routes of chemical exposure may vary in degree of importance among various test systems.

Sensitivity to LAS differed among aquatic life stages of *C. riparius*. While eggs were relatively insensitive, increased sensitivity was observed following the emergence of the posthatch, first instar larvae from the matrix.

## RELIABILITY

Klimisch score

2a (acceptable, well-documented publication which meets basic scientific principles): no GLP