Council for LAB/LAS Environmental Research

LAS BIODEGRADATION IN UNTREATED WASTEWATER DISPOSAL

Untreated wastewater discharge is a common occurrence in many parts of the world, and yet there is very little data to form an environmental risk assessment. Conducting widespread monitoring studies of these types of locations on a global basis would be a tremendously ambitious and costly undertaking. A risk assessment for untreated wastewater discharged has been carried out and reported in two publications. The studies, which focus on the Balatuin River in the Philippines, demonstrate:

1) LAS biodegrades faster than other biodegradable compounds (measured as BOD, biochemical oxygen demand), so that BOD concentrations are still high after LAS concentrations have been reduced to insignificant (background) levels.
2) Other critical water quality factors, such as dissolved oxygen (DO) and ammonia return to normal levels after BOD concentrations are reduced.
3) The results demonstrate that BOD, DO and ammonia are critical factors for determining water quality of rivers and streams receiving untreated wastewater. LAS concentrations, which may be high in untreated wastewater, are not a critical factor.

First Study

The first paper, by Dyer et al., focuses on the influence of physical and chemical factors — including levels of LAS — on aquatic communities in the river, including algae, invertebrates, and fish.[(1)] The study included nine sampling sites (six along the Balatuin River and three point sources) spread over approximately 10 miles. The sample sites ranged from residential areas that had piggeries and included direct discharge household wastes from bathing, washing of clothes including use of laundry products containing LAS, household cleaning, human wastes (urine and feces) and other solids and plastics as well. Key points that emerged from the study of the Balatuin River are:

- The study found that the critical factors impacting aquatic communities were low dissolved oxygen (DO) levels and high ammonia concentrations.

- Perhaps not surprising was the observation that river water quality was poorer at sampling points located in highly populated areas, likely due to higher waste loading at these sites.

- Sampling sites down river from those with the poorer water quality exhibited higher levels of dissolved oxygen and hence improved water quality, due in part to the purification process of the river itself.

- An initial risk assessment may be conducted for LAS concentrations in down-river sampling sites. The first step was to determine a Predicted No Effect Concentration (PNEC) for aquatic organisms. For LAS there is an extensive database and the PNEC for the most sensitive 5% of the aquatic population ($PNEC_{0.05}$) – in other words, a PNEC that protects 95% of the aquatic population - can be determined. The $PNEC_{0.05}$ for LAS with an average alkyl carbon chain length of C12 (C_{12}-LAS) was determined to be 245 micrograms LAS per liter (245 μg/L) or (0.245 milligrams/L (0.245 mg/L).

- The concentration of LAS measured at six sampling sites on the Balatuin River ranged from 0.003 mg/L to 0.12 mg/L.

- Measured LAS concentrations in the Balatuin River are below the $PNEC_{0.05}$ indicating no adverse effect from the presence of LAS in the river water at any of the six sampling sites.

Second Study

The second study, by McAvoy et al., reports the results of a risk assessment model developed for untreated wastewater discharge containing consumer product ingredients.[2] The model involves an impact zone concept in which the river can be thought of as a natural wastewater treatment system. After the river has recovered via "self-purification" (reductions in levels of biodegradable organic compounds, measured as biochemical oxygen demand (BOD), restoration of normal dissolved oxygen (DO) levels and conversion of ammonia to less toxic compounds), it can be assessed by traditional risk assessment methods, focusing on BOD, DO and ammonia concentrations as critical parameters. This model (the QUAL2E model[3]) was validated using data obtained from the same river discussed above (the Balatuin River as discussed in the Dyer et al. paper). Sampling sites ranged over an approximately seven miles stretch of the river.

- A key takeaway is that the data show that LAS biodegrades faster than BOD, the biodegradation of which is a key driver of low DO levels. Consequently, LAS concentrations are not critical factors which influence the risk assessment. LAS is certainly present in untreated wastewater. But this risk assessment shows that standard water quality parameters — BOD, DO, and ammonia — are in fact the critical factors for an aquatic risk assessment.

- The model simulation did an excellent job of predicting the observed LAS river water concentrations. This rate loss rate of LAS is very similar to a field derived loss rate determined by Fox et al.[4] and a laboratory derived value by Peng et al.[5] further supporting its use. A maximum LAS concentration of 150 μg/L was predicted below a

direct discharge site and by the time that parcel of water had reached the last sampling site in the study the LAS concentration was predicted to be 3 μg/L. This change accounts for a 98% loss of LAS over a 14 kilometer stretch of river and is similar to the removal in activated sludge wastewater treatment (McAvoy et al.,[6]).

- The 2- and 3-phenyl position isomers were being lost at a much greater rate than the inner 5- and 6-phenyl isomers within the impact zone. This shift in isomer distribution is similar to what is observed during activated sludge wastewater treatment where the primary removal mechanism of LAS is by biodegradation.[7,8] The similarity in the shift in the positional isomers is further evidence that the observed LAS removal in river water is due to biodegradation.

- To determine the concentration of LAS that would interfere with the self-purification process, the key processes involved need to be identified. These are digestion of BOD (ultimately leading to increasing DO) and nitrification of ammonia. Bressan et al.(9) reported a no observed effect concentration (NOEC) for LAS of greater than 200 mg/L for activated sludge (BOD) digestion and a NOEC of greater than 100 mg/L for nitrifying bacteria. Consequently, a conservative estimate of the self- purification PNEC for LAS is 100 mg/L.

- Based on the model simulation, the highest predicted LAS concentration in the impact zone was 150 μg/L. Using this value for the impact zone Predicted Environmental Concentration (PEC) and the PNEC of 100 mg/L yields a risk quotient (PEC/PNEC) of 0.0015, which indicates low risk and no cause of concern.

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Updated October 2018