

Ecotoxicology Division

Assessing the Environmental Performance of Drilling Fluids

In regulatory approved circumstances, the cost of treating and discharging drilling wastes from platforms into the surrounding ocean is often lower than the cost of transportation back to shore. In Western Australia, the Department of Industry and Resources (DoIR) adopts a holistic environmental risk assessment approach for regulating the use and discharge of drilling fluids (including drilling fluids adhering to cuttings).

Integral to the DoIR risk assessment framework is evaluating the 'environmental performance' of a drilling fluid. In keeping with the regulatory measures implemented in the United States, Canada and the OSPAR signatory countries of Europe and the United Kingdom, evaluating the environmental performance of a drilling fluid requires an understanding of:

Ecotoxicology

Biodegradation

Bioaccumulation / Bioconcentration

Geotech's experienced Ecotoxicology Division offers a convenient and complete risk assessment service with capabilities designed to meet the regulatory requirements for evaluating the environmental performance of a drilling fluid.

Ecotoxicology

The DoIR regulatory guidance documents require acute and chronic toxicity testing to be performed on water soluble and particulate phases of drilling fluids. Toxicity testing provides valuable information with respect to the bioavailability of a drilling fluid and assists the regulator in understanding the potential for adverse ecological effects. Results from the acute and chronic toxicity testing program can then be used to ascertain the environmental risk of contamination from discharging the drilling fluid.

Standard acute toxicity tests (which measure short-term lethality or mortality) are acceptable for assessing the toxicity of a drilling fluid. However, chronic toxicity tests (which measure long-term sublethal effects such as reproduction, growth and fecundity) are now recognised as being more environmentally relevant for assessing the long-term effects of drilling fluids which may persist at low concentrations.

Toxicity tests which utilise representative organisms encountered in the receiving environment are preferable when assessing the environmental performance of a drilling fluid. Geotech offers a range of acute, sublethal and chronic toxicity tests using a suite of organisms including bacteria, microalgae, macroalgae, molluscs, crustaceans and fish. These toxicity tests have been specifically developed for the temperate and tropical aquatic ecosystems of Western Australia and the North West Shelf and are considered to be suitable surrogates by the European and United States regulatory agencies

Geotech can also develop and validate toxicity tests using non-standard species and methodologies to meet region specific regulatory requirements.

Toxicity Tests for Water Quality Assessment



Bacteria
 15-min Microtox®
Vibrio fischeri



Microalgae
 72-hr Cell Division
Isochrysis galbana
Chlorella protothecoides



Macroalgae
 72-hr Germination
Ecklonia radiata



Macrophytes
 7-day Frond Production
Lemna minor



Molluscs
 48-hr Fertilisation & Development
Mytilus edulis
Saccostrea glomeratus



Crustaceans
 21-day Reproduction
Glyptodendurus imparipes
Ceriodaphnia dubia



Echinoderms
 72-hr Fertilisation & Development
Helicodendron erythrogramma



Fish
 7-day Growth
Pagrus auratus
Danio rerio

Toxicity Tests for Sediment Quality Assessment



Amphipods
 10-day Survival
 6-week Reproduction
Melita plumulosa
Grandidierella sp.



Bivalves
 10-day Survival and Reburial
 6-week Growth
Spisula trigonella
Tellina sp.



Polychaete worms
 10-day Survival and Reburial
Australonereis ehlersi



Gastropods
 10-day Survival
Batillaria australis
Velacumantus australis

Biodegradation

Biodegradation is a typical measure of the drilling fluids persistence in the environment. Estimations of persistence using aerobic biodegradation (simulating drilling fluid at the surface of the cutting piles) and anaerobic biodegradation (simulating drilling fluid within the cutting piles) studies are required. Geotech offer both aqueous and solid-phase analyses to determine the rate of aerobic and anaerobic biodegradation. The tests generate a biodegradation curve that can be used to calculate the half-life of the drilling fluid. Specific physico-chemical testing conditions (such as temperature and salinity) can also be tailored to better replicate the receiving environment.

In addition, simultaneous toxicity testing of the degradation products can be incorporated into the studies to demonstrate changes in bioavailability and toxicity with biodegradation.



Bioaccumulation & Bioconcentration

Bioaccumulation refers to the uptake and retention of contaminants by an organism. Geotech estimate bioaccumulation using the standard Octanol-Water partitioning coefficient (Log P_{ow}). When the Log P_{ow} exceeds the regulatory threshold, the potential for bioaccumulation is considered significant. In the North Sea, the Chemical Hazard Assessment and Risk Management (CHARM) group suggests significant bioaccumulation has occurred when Log $P_{ow} > 7$. For OSPAR signatory countries, the threshold is more protective (Log $P_{ow} > 3$). Exceeding the threshold indicates there is a strong potential for transferring bioaccumulated contaminants through the aquatic food chain. In this situation, additional investigations of bioaccumulation (including whole sediment toxicity testing and bioconcentration analyses) are necessary.

Whole sediment toxicity testing offers an environmentally realistic representation of the sediment-associated contaminant bioavailability a benthic organism is likely to encounter. Toxicity will depend on the chemical speciation of the contaminant, sediment-water partitioning relationships and the physiology and behaviour of the benthic organism. Geotech offers a range of ecologically relevant whole sediment toxicity tests utilising acute, sublethal and chronic endpoints for a range of benthic marine organisms (including crustaceans, molluscs and polychaete worms) which have been specifically developed for the temperate and tropical aquatic ecosystems of Western Australia and the North West Shelf. Whole sediment toxicity testing is also recommended for assessing the risk of discharging cuttings associated with drilling fluid residue.

Bioconcentration estimates relate to the net accumulation of the contaminant resulting from simultaneous uptake and depuration. Expressed as a Log Bioconcentration Factor (Log BCF), the ratio of the contaminant concentration in the organisms tissue compared to the ambient concentration in the environment is used to calculate the Log BCF. Geotech can determine the Log BCF using the bivalve *Mytilus edulis* in controlled laboratory and in-situ field biomonitoring studies.



Example of the bivalve '*Mytilus edulis*' utilised in bioaccumulation and bioconcentration studies.

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