Assessing petrochemical effluents using mesocosms:

Comparison of predicted toxicity and laboratory and mesocosm measured toxicity of petrochemical effluents

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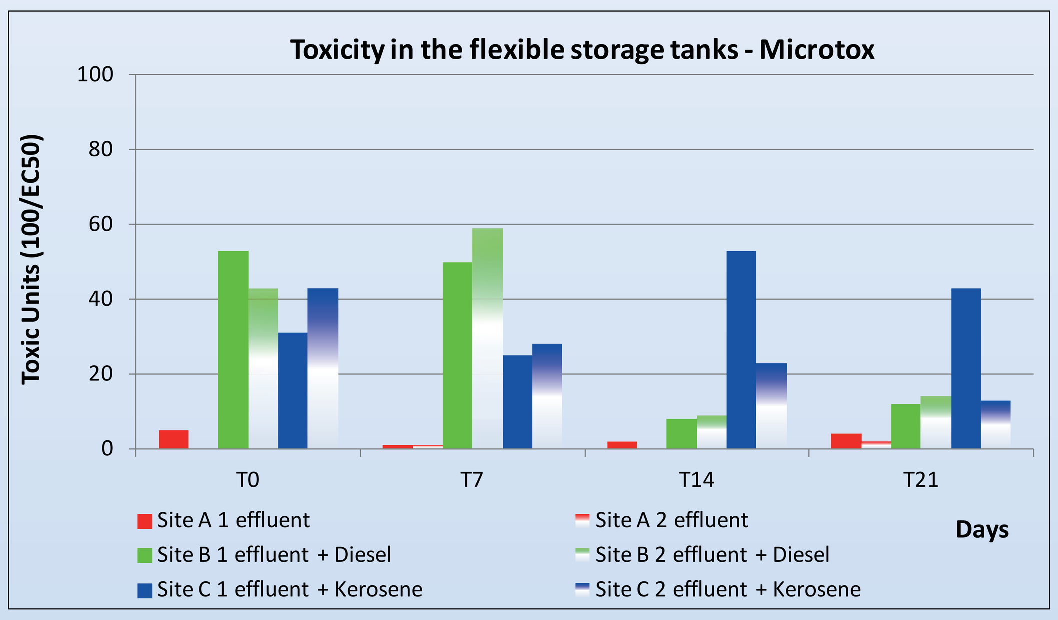
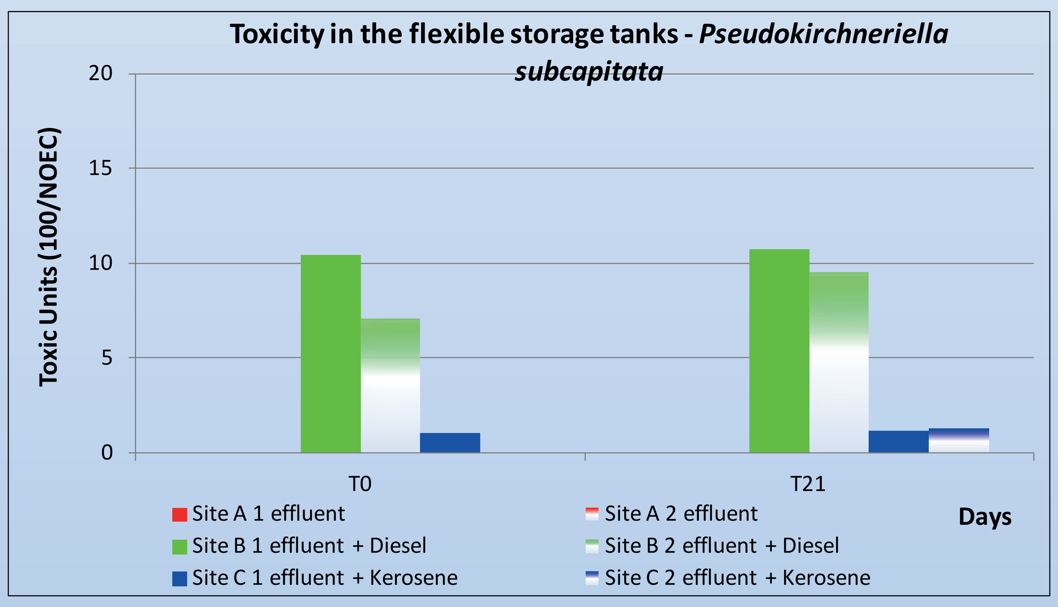
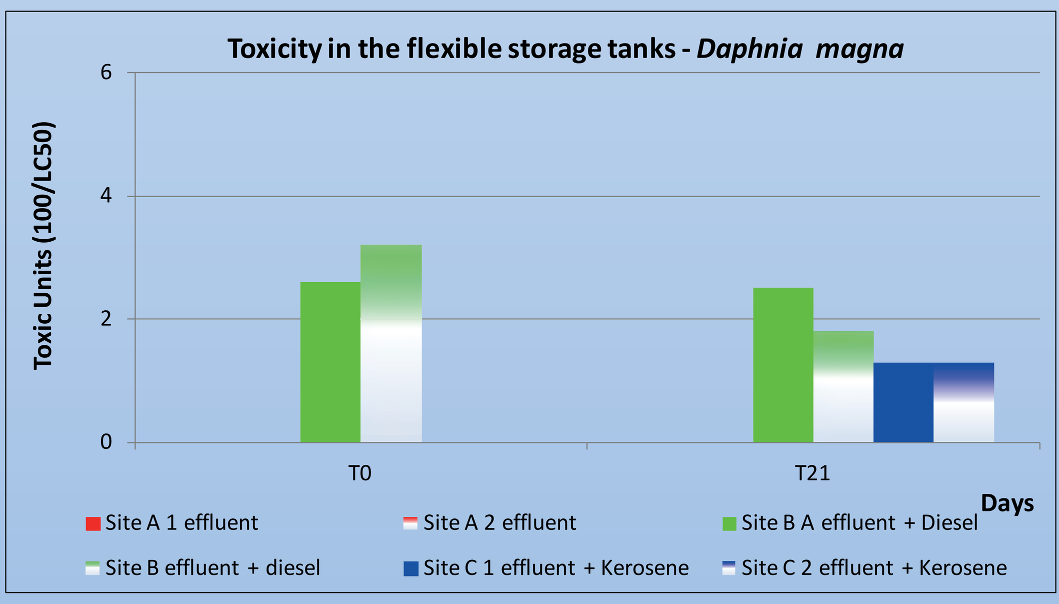
INTRODUCTION

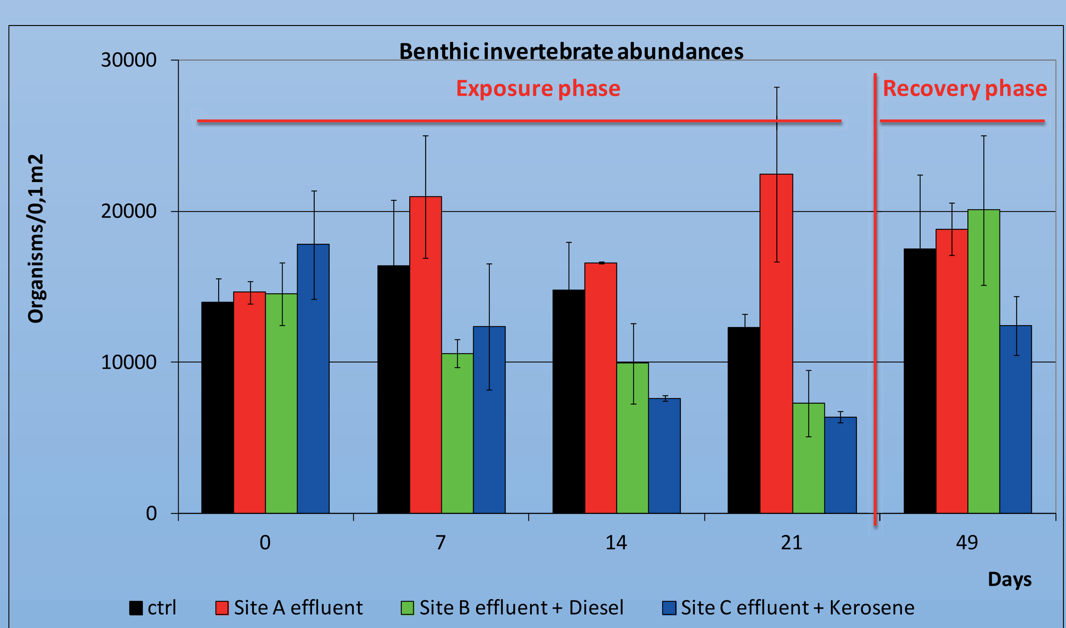
A study has been carried out to determine whether the toxicity of refinery effluents (pure and fortified with a petroleum distillate fraction), that was determined in laboratory tests, could be predicted on the basis of compositional data using a toxicity prediction tool (PETROTOX, Redman et. al., 2012) which has specifically been developed for the purposes of deriving the toxicity of complex mixtures of hydrocarbons to aquatic organisms. The expected toxicity of the effluent samples prior to introducing them to outdoor artificial stream mesocosms was predicted on the basis of an established relationship between their extractable hydrocarbon content, as determined by solid phase micro-extraction (SPME) and previously reported toxicity thresholds (Parkerton et al., 2001). The validity of the predictions was then tested by observing effects on ecological indices observed in the stream mesocosms which have been described in other posters (Cailleaud et al, 2013a and 2013b). Effluent and stream water samples were analysed by high resolution GCxGC, enabling the hydrocarbons constituents present in the samples to be assigned to hydrocarbon blocks, the toxicity of which could be predicted using the PETROTOX model. Observed effects on ecological indices in the streams could then be compared with expected effects based on the predictions.

Laboratory aquatic toxicity tests conducted on the fortified effluents
15/30 min Microtox acute toxicity
24 h *Daphnia magna* acute toxicity
72 h *Pseudokirchneriella subcapitata* chronic toxicity





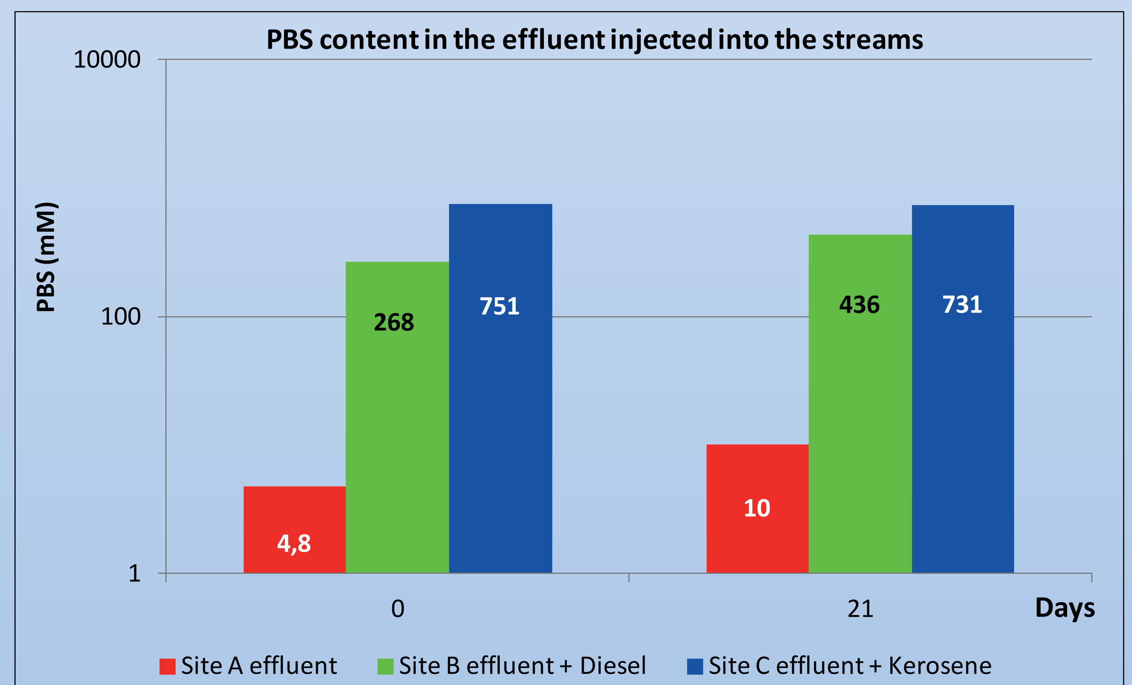




Indirect assessment of the toxicity of the effluents injected into the streams was addressed by measuring the extractable hydrocarbons (PBS), using solid phase micro-extraction (SPME) (Leslie *et al*., 2005). Using this approach, the fortified effluents were predicted to be very toxic, exceeding the acute toxic threshold concentrations for plants, invertebrates and fish (Parkerton *et al*., 2001).

The data also showed that the predicted toxicity was relatively constant throughout the course of the study.

ENDPOINT	Critical Cfiber (mM)	REFERENCE
Acute narcotic effect – trout	77	Parkerton *et al., 2001*
Acute narcotic effect – plant	57	Parkerton *et al., 2001*
Acute narcotic effect – *Daphnia magna*	42	Parkerton *et al., 2001*
Chronic narcotic effect – *Daphnia magna*	8	Estimation based on ACR of 5

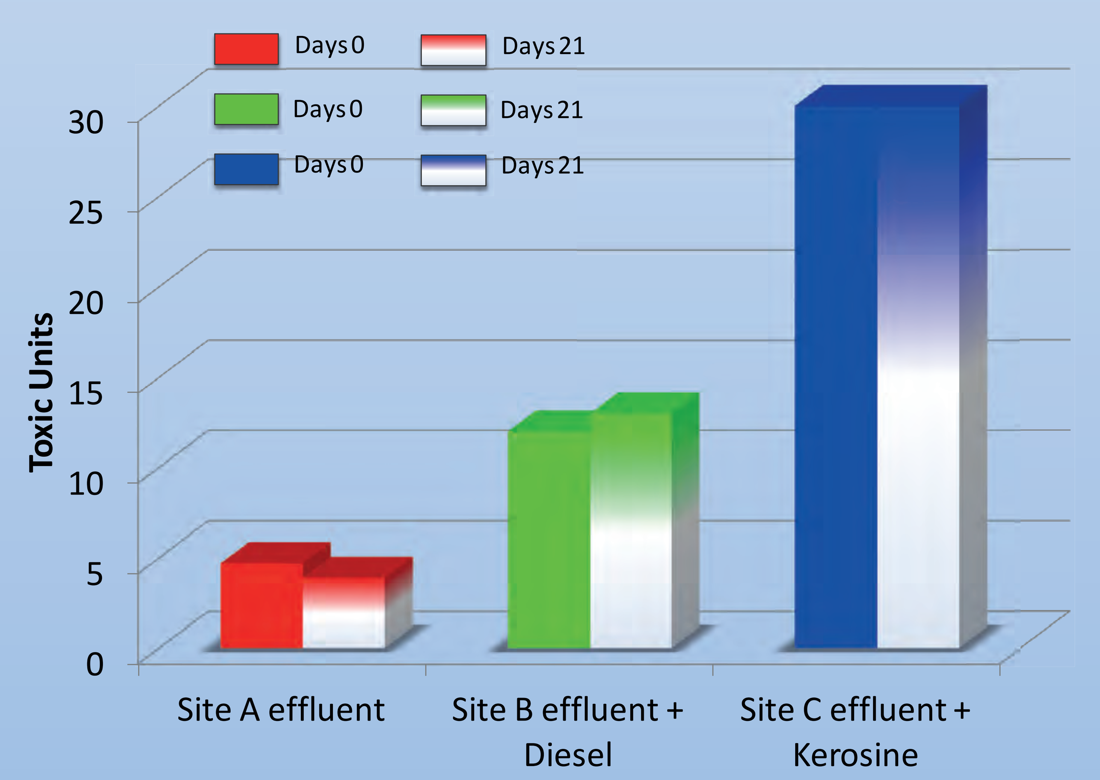


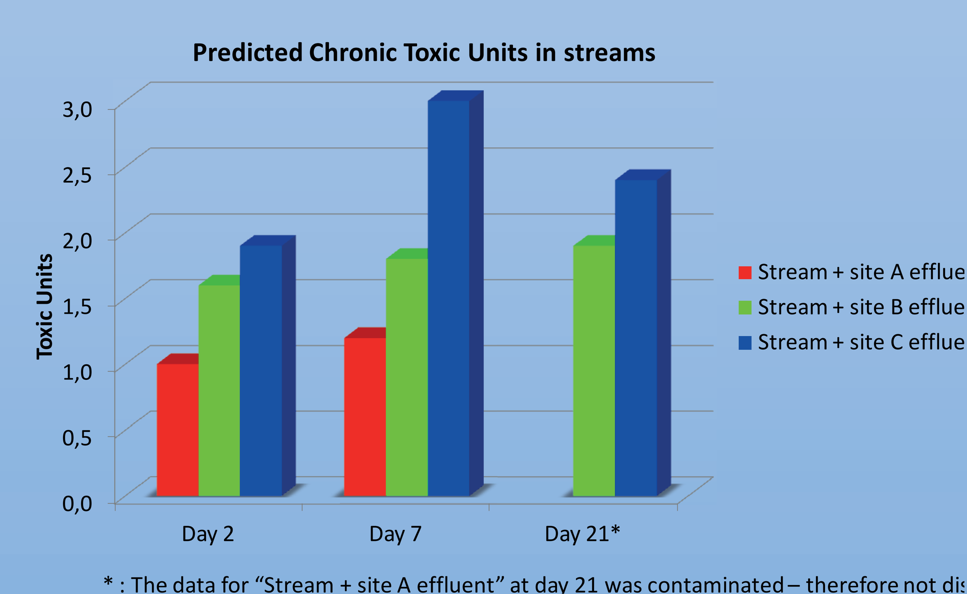
Modelled ecotoxicity of undiluted effluent and stream water samples - Samples were analysed by high resolution GCxGC, enabling the hydrocarbons present in the samples to be assigned to appropriately described hydrocarbon blocks. The (acute or chronic) toxicity of these samples was then predicted using the PETROTOX model.

	Toxic Units – *R.abronius*	Toxic Units – *Chlamydomonas reinhardtii*	Toxic Units – *Daphnia magna*	Toxic Units – *Oncorhynchus mykiss*
Site B effluent + Diesel	9.5	6.1	2.3	4.5
Site C effluent + Kerosine	3.9	1.8	1.0	1.8

The table above shows the predicted acute toxicity for plants, invertebrates (in marine and freshwater) and fish. These predictions reflect the similarity of response that is usually observed for chemicals acting through a non-specific mode of action (narcosis). Data for the invertebrate, *Rhepoxynius abronius,* are also shown in the table above, since this is the most susceptible species in the PETROTOX database, and is used for all the comparisons in the figures below. A Toxic Units sum value of $\geq$1 indicates that the threshold for toxic effects to occur has been equalled or exceeded.

Predicted Chronic Toxic Units for effluents in streams





CONCLUSION

1. COMPARISON OF LABORATORY TEST RESULTS WITH PETROTOX PREDICTIONS: the laboratory studies clearly show that prior to dilution all the fortified effluents injected into the stream were toxic (acute or chronic) to all of the test organisms, with the toxic units varying from approximately 2 (Daphnia), 1 – 10 (algae) and 20 – 60 (Microtox). The data was supported by the PBS measurements of these samples and by the PETROTOX predictions. The latter predicted toxic units for acute toxicity for the most sensitive species in the PETROTOX database (R. abronius) of 10 – 30 for the fortified effluents and approximately 3 for the unfortified effluent.

2. COMPARISON OF PETROTOX PREDICTIONS WITH OBSERVED EFFECTS IN STREAMS: the impact of the effluents on the stream communities has been discussed in an accompanying poster (Cailleaud et al., 2013b). In summary, the data indicated that the various communities were affected by both the fortified effluents, but not by the unfortified effluent. This is in reasonable agreement with the PETROTOX predictions, which also suggest that some effects could have been expected in the stream fed with the unfortified effluent, although the comparable magnitude of the effects needs further investigations. These data suggest that PETROTOX is conservatively predicting the potential effects of the effluents in the streams and can be used as a complementary tool to assess effluent impacts .

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