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Bio-monitoring of produced water from an oil field

New research has examined the impact of Produced Water (PW) discharges from a Norwegian oil field, using mussels to monitor the quality of the environment. The findings indicated the effectiveness of a bio-monitoring approach to study the chemical and biological influences of off-shore exploitation activities.

Produced Water (PW) is a mixture of formation water contained in the oil reservoir, injected water from secondary oil recovery and treatment chemicals added during production. PW is discharged from oil production platforms and often contains various pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and alkylphenols, which bioaccumulate in marine organisms and may threaten the environment.

Under the EU Marine Strategy Framework Directive[1], the marine environment must achieve or maintain good environmental status by 2020. PW is a chronic source of pollution and there are concerns to possible long-term impacts on the environment. Estimates of the PW discharge volume predict an increase on the Norwegian shelf until 2014, reaching about 200 million litres per year. Of the pollutants, PAHs are known to induce toxic effects at the individual level. Thus there is a need for adequate exposure and effect markers used in bio-monitoring of off-shore discharges. By integrating chemical analyses with biomarker responses in organisms, the effect of toxic chemicals present in the water can be calculated.

The researchers conducted a combination of controlled laboratory experiments and a field survey on mussels, using both chemical and biological markers, to study the impact of PW from the North Sea Ekofisk oil field. In the laboratory, 100 mussels were exposed to eight tanks of different concentrated PW for 29 days, whereas the field investigation was performed for 48 days using six cages about 200 to 2000 metres from the discharges. Another two cages were placed in clean areas and used as a control. The chemical and biological markers used were PAH bioaccumulation, lysosomal membrane stability (LMS) and micronuclei (MN) assays, respectively.

The laboratory results revealed that PAH bioaccumulation increased in the mussels' soft tissue, even at the lowest PW exposure. Naphthalenes were the most common compounds detected and represented 80% of the total PAHs in the water. Also, the frequency of MN increased as the concentration of PW increased, whereas LMS had a tendency towards a response depending on the PW concentration.

Similarly, in the field study, the biomarker analyses depended on the contamination level. All mussels caged in the platform area had higher levels of PAHs in the soft tissue compared to those in the clean region. The accumulation pattern followed a gradient depending on the distance, with the highest values found in mussels from places closest to the PW discharge. However, overall, the PAH-level in mussels from the field exposure were lower than the ones from the laboratory exposure.

The combination of laboratory and field experiments strengthened the general findings of this study. They also validated the selected markers and improved knowledge about their potential and limitations. The differences in the results between the two may be explained by the continuous exposure of PW in the laboratory and the fluctuating exposure in the field. As the study indicated, in addition to the traditional chemical approach, which is useful for confirming exposure of the animals to PW, biomarkers should also be a part of the health assessment and management of aquatic ecosystems. The authors also demonstrated the effectiveness of mussels as sentinel organisms in off-shore PW monitoring. Thus, the ecotoxicological approach used in this study is suggested for future off-shore bio-monitoring programmes.

1. See: http://ec.europa.eu/environment/water/marine/ges.htm

Source: Sundt, R.C., Pampanin, D.M., Grung, M., *et al* (2011) PAH body burden and biomarker responses in mussels (*Mytilus edulis*) exposed to produced water from a North Sea oil field: Laboratory and field assessments. *Marine Pollution Bulletin*. 62(7):1498-1505.
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