WORKSHOP ON DRILLING FLUIDS (WDF)
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GREENPEACE INTERNATIONAL SUBMISSION TO THE WORKSHOP ON DRILLING FLUIDS

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1. Introduction

Concern over environmental impact of discharge of drill cuttings contaminated with drilling muds (drilling fluids) has existed for some time. Despite recovery of the drilling muds, the cuttings, frequently heavily contaminated with production and well chemicals, are routinely discharged to the seabed without further treatment. Besides the physical impact, concerns have been raised over the toxicity of oil residues in discharged cuttings. These led to PARCOM Decision 92/2 on the Use of Oil-based Muds, and moves by some North Sea states to recover contaminated cuttings to shore and develop alternative muds with a lower toxicity base. Despite this, the oil content of discharged cuttings may still be high. This, along with the presence of other production chemical residues, is an issue of serious concern and one requiring urgent action in order to minimise further impacts.

2. Toxicity of drilling muds

2.1 The toxicity of oil-based mud (OBM) residues to marine fauna has been fairly well documented, and includes impacts on feeding, settlement and reproductive development in bivalves [1,2,3] and on immune response in fish [4]. Elevated concentrations of oil in sediments have been detected up to 5-10km away, even from small groups of wells using oil-based muds [5,6]. Washing of cuttings from OBM operations prior to discharge may reduce the severity of effects, but generally has little influence on the area impacted [5]. The Danish EPA and Energy Agency request avoidance of OBM wherever possible, for reasons of both occupational safety and environmental impact (SEBA 97/4/5-E). Nevertheless, OBM are still used in some areas of the North Sea.

2.2 Alternatives to OBM include fluids using organic compounds (synthetic muds, SM) or water (water-based muds, WBM) as base agents. Conditions within much of the UK sector apparently demand the use of SMs rather than WBMs (SEBA 97/5/4-E). These alternative bases may also be persistent and/or exert toxic effects on benthic organisms. Although, according to the definition presented by Norway (SEBA 97/5/5-E), fluids with an olefin (alkene) base are not considered as OBMs, persistence for several olefin formulations tested by the UK was similar to, or even greater than, that for a mineral oil base (SEBA 97/5/1-E). In addition, it is acknowledged by Norway that many of the chemicals in SMs have a high potential for bioaccumulation (SEBA 97/5/5-E). For those synthetic bases which do degrade more rapidly, most notably the ester bases, toxicity and oxygen depletion remain as problems. For example, Daan *et al.* [7] reported impacts of ester-based muds on sensitive species (sea urchins) even 1 year after drilling had ceased.

2.3 Even in operations using WBMs, drill cuttings can become contaminated with other production chemicals and oil from the well itself, probably accounting for some of the toxicity observed. Exposure of larval and adult marine invertebrates to water-based muds in use off southern California revealed some toxic effects in brown cup corals and impacts on settlement of red abalone [8]. Although this latter response would not be detected using standard toxicity tests such as those employed in the CHARM model, the potential implications for community structure are, nevertheless, severe.

3. Extent and duration of impact

Recent evidence indicates that the impact zone surrounding drilling or production installations may be substantially greater than previously assumed. Caged mussels 5 km down-current from cuttings discharges have been found to contain higher than background tissue oil concentrations [9]. While major impacts on benthic organisms may generally be restricted to an area of 250m radius around a platform, effects on overall community structure have been detected as far as 2-6 km from disused platforms in the North Sea [6]. These authors also reported contaminated areas of between 10 and 100 km^2 surrounding the Veslefrikk and Valhall oil fields respectively, and concluded that "Effects on the fauna closely followed the patterns of contamination…the areas showing effects were only slightly less than the areas contaminated".

In contrast, a review of environmental effects of cuttings discharges presented by the UK (SEBA 97/5/3-E) concluded that biological communities generally return to normal within 2 km of installations and that the area of chemical contamination is wider than that of biological impact. In the light of the findings outlined above, the conclusions of this review may need to be revisited.

If drill cuttings are not recovered, redistribution on currents can lead to continued increase in the area contaminated for many years after discharge has ceased [5]. Degradation of oil residues is inversely related to the level of contamination (up to 0.5% hydrocarbon by weight), the lowest rates corresponding to highest residue concentrations (SEBA 97/5/1-E). Within the cuttings pile itself, biodegradation may be negligible, even over extended periods (SEBA 97/5/3-E) [7]. Although accelerated degradation may occur at the periphery, this could in turn result in localised enhancement of oxygen depletion, or of toxicity, bioavailability or dispersal of contaminants.

4. Greenpeace's analyses of drill cuttings

In July 1997, Greenpeace collected samples of sediment from three former or current drilling sites and one remote reference station in the North Sea. These were screened for organic contaminants (using GC/MS) at the Greenpeace Research Laboratories, University of Exeter, UK, and sub-samples forwarded to the laboratory of TNO in the Netherlands for quantitation of n-alkanes (C9-C40).

4.1 Organic screens revealed very high levels of oil contamination in samples from all three drilling sites. At the two sites active in 1997, adjacent to the Henry Goodrich and Stena Spey rigs, long-chain alkenes were the dominant contaminant group, suggesting the use of olefin-based drilling muds. At the third drilling site, Transocean 9, n-alkanes predominated. Drilling at this site ceased in 1996; the presence of oils therefore indicates carryover of contamination from previous operations, arising either from use of OBMs or as contaminants from the well itself. High levels of oil contamination at the drilling sites were confirmed by the results from TNO (Table 1). At both Henry Goodrich and Stena Spey sites, the 1% limit under PARCOM Decision 92/2 was exceeded (by 6.6 and 6.5 times respectively). Had alkenes been quantified, total oil-residue concentrations would

	Henry Goodrich	Stena Spey	Transocean 9	Reference
nonylphenol (mg/kg)	1.1	0.4	30	<0.04
C9-C40 alkanes (%)	6.6	6.5	0.56	<0.002
water content (%)	41.3	43.4	24.6	41.0

Table 1: Quantitative analytical data for nonylphenol (expressed as mg/kg dry weight of sediment) and n-alkane concentration (expressed as percentage dry weight of sediment) in three samples of sediment collected adjacent to North Sea offshore drilling sites and a fourth from a reference location. Samples analysed by laboratory of TNO, Netherlands.

have been even greater. Levels at the Transocean 9 site did not exceed this limit but were substantial nevertheless. At the reference site, alkanes were below limits of detection. Although toxicity tests were not conducted, from the levels of oil reported it is reasonable to expect some lethal and/or sublethal effects in the vicinity of the drill cuttings discharges.

4.2 In addition to n-alkanes, the production chemical derivative nonylphenol was also quantified in all four samples. Concentrations varied from 0.4 mg/kg (dry weight) at Stena Spey to 30 mg/kg at Transocean 9. Levels at the reference site were below limits of detection. These results indicate that the toxic, persistent and bioaccumulative chemical nonylphenol is being released into the North Sea environment as a result of its use, or use of nonylphenol ethoxylates, in production chemical formulations. On the basis of the Results of the Questionnaire on the Uses of NPEs and similar Substances, presented by Sweden to DIFF 1995, the most likely sources appear to be use as detergents and emulsifiers (DIFF 95/9/1-E).

Recognition of the toxicity and persistence of the alkylphenols led to PARCOM Recommendation 92/8 to phase out use of nonyl and octylphenol ethoxylates in household (by 1995) and industrial (by 2000) detergents. More recently, concerns have been raised over the ability of the alkylphenols to interfere with hormonal communication and sexual development in fish [10,11]. Although much of the research relates to freshwater fish, the limited evidence to date indicates that similar effects can occur in estuarine [12] and marine fish [13]. In light of the endocrine disrupting properties of these chemicals, Sweden has indicated that it will call for a binding decision under OSPAR to eliminate all uses of APEs and APs which lead to releases to the environment [14]. This would necessarily include offshore production chemicals. Steps have already been taken by some delegations (notably Denmark) to substitute all offshore uses of alkylphenols (SEBA 97/7/Info.1-E).

5. Regulation of discharges

In the mean time the discharge of offshore production chemicals in drill cuttings continues to be poorly documented and regulated. Under PARCOM Decision 96/3, all applications to use or discharge offshore production chemicals should be accompanied by detailed composition and hazard information according to the Harmonised Offshore Chemical Notification Format (HOCNF). The CHARM model, which is central to the process of ranking of chemicals according to hazard, is limited in scope, relying heavily on lethal toxicity tests with insensitive organisms. In the past it has suffered from lack of information on chemicals in use as a result of commercial confidentiality of proprietary formulations. Norway notes that existing bioaccumulation tests under HOCNF are inappropriate for many surface active agents included in drilling fluid formulations and may yield poor estimates of accumulation in sediments (SEBA 97/5/5-E), while the Netherlands criticises the current exclusion of fish toxicity tests for sediment-oriented chemicals (SEBA 97/7/7-E). In addition, ongoing revision of the CHARM model renders its routine application limited. As highlighted by Denmark, the introduction of the third revision in December 1996 necessitated a period of re-evaluation and preliminary testing of the model as experience with the new version within the Danish Authorities was, understandably, very limited (SEBA 97/7/Info.1-E).

6. Conclusions

Greenpeace International's findings, mainly the exceedence of the 1% limit under PARCOM Decision 92/4 reported here for samples of drill cuttings taken adjacent to two current operations in the UK sector, show that further investigations are urgently required. Nevertheless, even if current legislation were strictly adhered to, substantial contamination of, and effects on, marine communities would still occur. Discharge of such wastes, and in such quantities, to the marine environment would be unlikely to be permitted from land-based sources.

If, as intended, implementation of HOCNF proceeds through mandatory toxicity tests on a chemical by chemical basis, discharge of certain hazardous chemicals can be expected needlessly to continue for some time to come. The range and sheer complexity of drilling fluid formulations will render such an approach laborious and one which is unlikely to yield information useful for the prediction of toxicological interactions in chemical mixtures.

As noted by Denmark (SEBA 97/7/5-E), consideration must be given to existing, published information under HOCNF. Such a scheme would also allow consideration of sub-lethal effects on sensitive organisms, where such information existed. Toxicological (and other hazard) information may already be sufficient for some chemicals or groups of chemicals, routinely employed in drilling fluids, to be withdrawn from use with immediate effect on a precautionary basis. For example, given that the alkylphenols are widely recognised as toxic, persistent, bioaccumulative and endocrine disrupting chemicals, they could be prioritised for elimination without the need for additional toxicity testing.

Furthermore, we note that Appendix 2 of the Draft PARCOM Decision on Substances/Preparations Used and Discharged Offshore (OSPAR 97/4/4), listing substances that shall not be discharged, is currently empty. On the basis of the information presented above, we propose that nonylphenol and, indeed, the alkylphenols as a group, be included in Appendix 2.

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