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Potential risk of environmental effects by the PAH contamination from wet scrubber effluents in the planned Reyðdarfjörður Aluminium smelter

Jonny Beyer

RF-Rogaland Research, P.O.box 2503 Ullandhaug, 4091 Stavanger, Norway.

Scope

This document contain a preliminary evaluation of the potential risk of environmental effects connected to the planned release of PAH in seawater effluents from the wet scrubber in the proposed aluminium plant at Reyðdarfjörður. The present evaluation is based on chemical data and physical background material given in a section of the assessment report by Vatnaskil Consulting Engineers (Vatnaskil 1999). In this evaluation, a short introduction to the marine PAH as an environmental issue is given, followed by a evaluation of the planned PAH release in the Reyðdarfjörður recipient as compared to relevant data from the Karmsund strait in SW-Norway, the marine recipient of Hydro Aluminium Karmøy (HAK). The potential risk of increased PAH levels in biota in the Reyðdarfjörður recipient area is briefly discussed.

Introduction

The release of effluents from aluminium works gas-scrubbers is a known source of PAH contaminants to marine recipients in Norway. Several PAHs are carcinogenic to humans as well as to wildlife. The pyrogenic types of PAH compounds produced in connection to aluminium production originate mainly from the consumption of tar-based anode materials (Næs and Oug 1997). Marine contamination by these PAHs is caused mainly by the release of effluents from gas scrubbers. The PAH in the scrubbing effluents is preferentially attached to or incorporated in microscopic soot particles. Much of these particles will normally settle at the sea floor relatively close to the plant. Hence, the levels of PAH in sediments in the vicinity of Al works may be very high (Naes et al. 1995). Generally, however, the PAH input to the marine environment has been lowered from the Al smelter industrial sector in Norway as a result improved smelter technology and the construction of settling basins for the scrubbing effluents. Due to these improvements many have regarded the PAH problem at Norwegian works mostly to be a historical issue, being located to sediments. Recent data indicate, however, that this statement is just partly true. In recipients of works that still utilises the Søderberg technology, the release of PAH appears to remain a significant environmental problem.

Bioavailability and effects of PAH in marine organisms

Since the PAH in scrubbing effluents is soot bounded, the bioavailability in seawater has been questioned. However, field investigations in the Karmsund strait have shown that the PAHs indeed are taken up by various species, ranging from mussels to fish (Beyer et al. 1997; Beyer et al. 1998; Ølberg 1998). Blue mussels, and other filter feeders, constitute the class of organisms being most at risk for accumulating high levels of soot bounded PAHs. Very high levels, also of carcinogenic PAH species, have recently been detected in blue mussels downstream the outfall of scrubbing effluents from HAK (Ølberg 1998). Also fish in this recipient take up PAHs. This is demonstrated by the detection of high PAH metabolite levels in bile fluid in both wild fish and in fish caged in the vicinity of the HAK scrubber effluent release (Beyer et al. 1998; Aas et al. in prep). Since the fish liver has an excellent capacity for metabolising PAH compounds the levels in tissues are generally low as compared to mussels. This is highly significant from a human consumption point of view. The bile fluid is the major excretion channel for PAHs in fish. Though being able to keep PAH tissue levels low; fish are highly vulnerable to adverse effects of PAH contamination. This is due to the toxicity of the PAH metabolites. Parent PAHs are relatively inert molecules, but the intermediate metabolites are highly reactive and may cause genetic injuries by generating PAH-DNA adducts. Field studies have shown that such effects occur in parallel with an increased incidence of hepatic preneoplastic lesions typically preceding various forms of liver cancer (Myers et al. 1987; Myers et al. 1994). Conclusively, the environmental effect of PAH on marine organisms is well documented, and several PAH compounds have therefore been classified as hazardous marine pollutants by important international bodies, such as OSPAR.

PAH in Reyðdarfjörður plant scrubbing effluents

According to data from Hydro Aluminium Metal Products (HAMP), the planned release of PAH in effluents from the Reyðdarfjörður smelter is calculated to be 3, 6 or 8 g/h depending on an annual production of 120, 360 or 480 000 tons of aluminium, respectively. As related to the various production numbers, the PAH release can thus be estimated at a range of 0.15 - 0.22 g per ton aluminium produced.

In comparison, the normal annual production at HAK is more than 200 000 tons (total capacity was 267 000 tons in 1997). The HAK scrubber effluents run through several settling basins prior to being released to the marine recipient. The PAH level in effluents is reported to be 2.8% of TOC. Based on TOC measurements of effluents and the reported effect the settling basins, the total amount of PAH released from the basins has been estimated to be approximately 450 kilo annually or 1.21 kg per 24 hours, and 50 g/h (all data HAK internal documentation reports prior to 1997). Based on a production range of 200 – 267 000 tons, this equalises a release in the range of 1.68 – 2.25 g PAH per produced ton.

As judged from these numbers it may be concluded that the amount of PAH released per produced ton of aluminium from the Reyðdarfjörður smelter lies approximately at 10% of the release from HAK.

Potential levels and effects of PAH in biota in Reyðdarfjörður recipient

In an Al-works recipient the PAHs may enter the food chain through sediment-linked processes or by uptake from the waterborne particles. Which of these routes that is dominating will depend on what species being studied, but also several other factors influence the actual uptake. The presence of old PAH contamination in sediments have been regarded generally as the major source of biotic uptake. This route of uptake will not be significant in the case of Reyðdarfjörður. However, studies in the Karmsund strait have demonstrated that also PAH attached to waterborne particles is highly bioavailable. This conclusion was drawn on basis of a study where fish that were caged at 10 m depth at the sediment floor in the most contaminated part of the Karmsund recipient displayed a weaker PAH uptake than fish caged at the same place but in the surface layer (Beyer et al. 1998). Recent investigations of mussels in this area support these observations. In particular in the area close to HAK very high PAH levels have been measured indicating significant contribution from present release (Ølberg 1998). Since the blue mussels are filter feeders they will exposed almost exclusively from PAH at waterborne particles.

Previously, the PAH contamination in Norwegian recipients has been regarded not to cause significant biological effects. However, all available biological effect parameters appear not to have been included in these studies. Recent and ongoing investigations in the Karmsund strait have identified adverse biological effects in blue mussels as well as in fish. In mussels, a clear depression of the lysosomal stability in hemocytes has been detected in a large part of the strait (Ølberg 1998). In two species of fish caught in the strait relatively high levels of DNA lesions in terms of BaP-DNA adducts have been found in liver tissue (Aas et al, in prep).

From our experience it seems obvious that PAH released in scrubbing effluents at Reyðdarfjörður will be bioavailable for marine organisms in the recipient. However, as compared to the situation in the Karmsund strait, both PAH levels and eventual biological impact levels in marine organisms will be much lower. Since the location do not contain previously contaminated sediments, the uptake in biota will occur from waterborne particles. The PAH levels in filter feeding mussels in the recipient should therefore be monitored before and after start of production. Studies on fish appear not to be needed, at least not before eventual high levels in mussels can be documented. The PAH levels in mussels in the vicinity of the outfall of the Reyðdarfjörður scrubber effluents may be expected to be around (or less than) 10% of the levels detected in the HAK recipient. An eventual high exchange rate of the seawater in the Reyðdarfjörður recipient will contribute to diminish the potential risk of increased biotic PAH levels even further, but this factor has not been considered in the present evaluation due to incomplete background material.

Conclusion

Overall, the planned aluminium smelter at Reyðdarfjörður appear not to represent any large problem in terms of the potential risk of increased PAH levels in marine organisms in the recipient. As compared to situations at larger works elsewhere, the planned release of PAH is of minor quantity. The effect on consumable seafood may only become problematic for mussels in the ultimate vicinity of the outfall of the scrubbing effluents. PAH levels in mussels at various distances from this location should therefore be monitored in some time (years) after the production start in order to verify the environmental quality of the recipient.

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