Polar and Non-polar Compounds in Produced Water

Environmental impact and toxicity of organic and inorganic trace compounds in co-produced water from North Sea oil fields

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Produced water (PW) is the water co-produced with oil and gas from oil wells and it represents the largest volume waste stream in oil and gas production operations on most offshore platforms. In 2021 there was an estimated 30 million tons of produced water discharged from the Danish continental shelf alone. Current regulations cover only the dispersed hydrocarbon content by the legal limit of 30 mg/L; this limit does not address the polar species, such as naphthenic acids, alkyl phenols and metals dissolved in the water which are potentially the most important drivers for toxicity in produced water. These polar compounds require more complex sample preparation techniques for analysis than non-polar hydrocarbons. For detailed analysis, samples of produced water discharge from the Danish South North Sea oil production wells are purged in charcoal trap for volatile analysis and then fractionated by Solid Phase Extraction (SPE) leading to the isolation of phenols and naphtenic acids and other organics. Naphthenic acids (NAs) comprise a wide range of aliphatic, cycloaliphatic and aromatic carboxylic acids, they act as surfactants and have been shown to be toxic to a variety of organisms especially in aquatic environments. Alkyl phenols are the products of the degradation of their precursors, alkyl phenol ethoxylates, a group of non-ionic surfactants used as detergents, emulsifiers, solubilizers, wetting agents and dispersants, Alkyl phenols are also naturally occurring in crude oil. The individual extracts are measured for target analysis with GC-MS and LC-ESI-MS. The focus on metals in the produced water has been on Ba, Sr, Fe, Co, Ni, Cu, V, Mn, Cr, Cd, Pb, As, Sb, and Se all of which occur naturally in the produced water and originate from the geological formation. Trace elements are challenging to measure in highly saline matrices such as sea water and formation water, and this work focuses on elemental characterization of elements present in low ppm and trace amounts for improved environmental impact assessment. All trace elements have been targeted in suspended particulate matter (SPM) and characterized using EDX-SEM and ICP techniques. In order to overcome the analytical challenges a matrix matching solution for blanks, calibration standards and quality checks has been implemented to improve ICP-OES/MS stability, and metal hydride analysis has been used analyze metalloids with a cleaner signal, which cannot be analyzed with standard ICP-OES/MS. The presentation will include the initial results of analyses of produced water from the post-separator discharge point of several wells from Danish North Sea offshore platforms.