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The offshore oil production in the Danish North Sea: What is the environmental impact of metals and metalloids in co-produced water?

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When crude oil is produced, significant amounts (10^6 m^3/year) of wastewater are made along with the raw material. This co-produced water (PW) is originally a formation brine contaminated by crude oil from the geological formation, but it also contains various production additives (anti-scaling, corrosion inhibitors, biocides...). Therefore, it is heterogeneous and chemically complex. Since this water is continuously discharged into the sea at most current offshore production sites, reaching the "zero harmful discharge" goal in 2050 requires stringent PW management, improved monitoring, and toxicology evaluation. Trace elements and metalloids are often challenging to measure in formation water brines and are hard to quantify reliably in many cases, affecting the regulations, annual reports, and tests. So, this work has targeted more abundant elements such as Ca, Mg, Sr, Ba, Fe, Mn, and those present in sub-ppm amounts (Cd, Pb, V, Hg, As) in produced water, improving the current environmental impact assessment and detect spatial and temporal variations. The concentrations considered the total and the suspended matter contribution. The results were obtained with ICP techniques (ICP-OES and ICP-MS) aided by dedicated equipment for metalloid analysis - Hg with CV/AFS and As/Sb with CV/ICP-OES. The analytical challenges of a hypersaline and carbon-rich water sample were overcome by optimizing standard methods (matrix-matched standards and blanks, microwave-assisted digestion).

The presentation will also include the initial results of inhibitory tests on *Vibrio Fischeri* luminescent bacteria and phytoplankton *Skeletonema sp*. using real produced water from Danish North Sea offshore platforms to understand better the role of transition and heavy metals for these organisms. The toxicity tests have been carried out on samples before and after hydro cyclones separation to indicate the contribution of individual species to the total toxic load.

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