The National IOR Centre of Norway

Environmental Risk Assessment (ERA) of IOR solutions on the Norwegian Continental Shelf

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Objective and target audience

The aim of the Environmental Risk Assessment (ERA) work at the IOR Centre is to provide methods, procedures, and key data to enable assessment of environmental risk in relation to IOR solutions (products and processes) elaborated at the center.

The objective of this report is to provide a user guidance summary on methods and tools to conduct ERA related to different IOR solutions. It will explain workflows, expertise, and tools needed in relation to different types of IOR solutions applied.

The report is foremost addressed to environmental engineers in the oil and gas industry, but will also be relevant for environmental managers, environmental authorities and regulators as well as for suppliers of chemical products and environmental services.

Introduction

Increased oil recovery (IOR) can be achieved by different methods and practices. Some involve use and discharge of added chemical compounds to the sea via produced water (PW) while others mainly imply altered amounts of discharged oil and PW from a field. Energy requirements and associated emissions to air as well as accidental chemical spill can also be involved, however, it is in essence the altered compositions and amounts of the operational discharges of PW associated with IOR solutions that are addressed here. The processes/solutions addressed in this report are:

a) ERA in general field applications
b) ERA of tracers
c) ERA of enhanced oil recovery (EOR) polymers
d) ERA of smart water and polymer flooding

Our work is focused on which of these can be assessed with existing ERA data and methods, identify which need new methods and/or data, and to propose and test new data and/or methods where needed. New data were needed for b), c) and d), while c) also needed new ERA method.

The environmental impact and risk of all operational discharges on the Norwegian Continental Shelf (NCS) are mandatorily assessed by the operators and approved by the environmental authorities. This is a repeated procedure during oil field lifetimes. Therefore, it is firstly addressed how ERA is conducted for PW discharges in general on NCS. Implementation of IOR solutions will in principle represent a modification in relation to the base case for each field.

a) Simply described, ERA is a combined calculation of how given discharges of PW constituents spread and dilute in the sea, combined with threshold values for environmental impact at the different concentrations in all exposed volumes of water to these constituents. A software simulation model tool is typically used for this purpose (e.g., Dynamic Risk and Effects assessment model (DREAM)). In this recommended practice, a real case is presented to exemplify the application of the DREAM model tool and its outputs and to serve as a base case for the second addressed point regarding ERA of tracers.
b) Tracers are commonly used to quantify residual oil saturation in inter-well regions of oil and gas reservoirs. The chemicals used as tracers must have certain properties acting against a too rapid degradation in the reservoirs and this persistence gives rise to a general environmental concern once these chemicals are released into the sea. The fraction of tracers recovered from the reservoirs and remaining in the PW stream after oil separation or cleaning processes will add to the chemical composition of the PW discharged over a time period. The contribution to the environmental risk of these

tracers can thus be evaluated by including (adding) their relevant data to a base case ERA, such as the one exemplified in a). Besides the amounts discharged, the information needed for the ERA is key data on toxicity, persistence (biodegradability) and biological accumulation potential of these chemicals. Laboratory tests on these properties have been conducted as part of the ERA work at the IOR center, making data available for the tracers evaluated at the IOR center. The tracers are used in relatively small amounts, and the environmental concern has foremost been related to the persistence of these chemicals due to relatively low biodegradation rates.

c) Enhanced oil recovery (EOR) can be achieved by injecting polymers to the reservoir. This group of chemicals will be used in much larger amounts than the tracers, and an environmental concern shared with the tracer chemicals is their persistence. For the polymers this is particularly due to a very slow depolymerization process that must take place before biodegradation can become effective. Literature data on this process as well as toxicity and biodegradability data are in general sparse for polymers, but considerable new knowledge has been gained through work at the IOR center. DREAM model is used to understand the concentration distribution of polymers after their release in the marine environment. The residual time of EOR polymer is calculated by linking the concentration distribution data of polymers with the depolymerization rate. A python script for calculating residual time is made available as a part of this project. At present, the uncertainty involved in the characterization of the environmental risk from polymers is high and due to lack of knowledge it is still not possible to recommend a practice of how to assess this risk. In the present report the approach under development at the IOR center is presented as a guide to the way forward regarding ERA of EOR polymers.

d) Use of smart water is a far less environmentally challenging IOR solution than polymer flooding EOR solutions. The constituents used are naturally occurring inorganic compounds, and the ERA can essentially be focused on the altered amounts of oil and/or PW that the applications will lead to in different fields. In some cases, the environmental impacts and risk can potentially be expected to be reduced with more efficient oil recovery. This will vary between types of fields, and the purpose here is not to present varying contributions to risk from the use of smart water at different fields, but rather to present how the risk contributions can be calculated and evaluated by using a case study focused on an (ensemble based) oil field production optimalization model.

Methodological Approach

In this chapter, firstly, a basic ERA methodology is presented and explained from the context of PW discharges to the marine environment. Next, the methods used for assessing environmental risk from individual IOR/EOR solution is described. Finally, the recommended practices for ERA of individual IOR/EOR solutions are discussed.

Basic ERA methodology

An ERA is a process of identifying and assessing the potential adverse effects on organisms, populations, or communities mainly due to exposure to chemical and non-chemical stressors from industrial activities (US-EPA, 1998). The basic methodology for conducting an ERA is well developed and adopted in several regulatory frameworks around the world and also used in scientific applications. There are four key phases involved in the basic ERA methodology that are explained below (Figure 1).

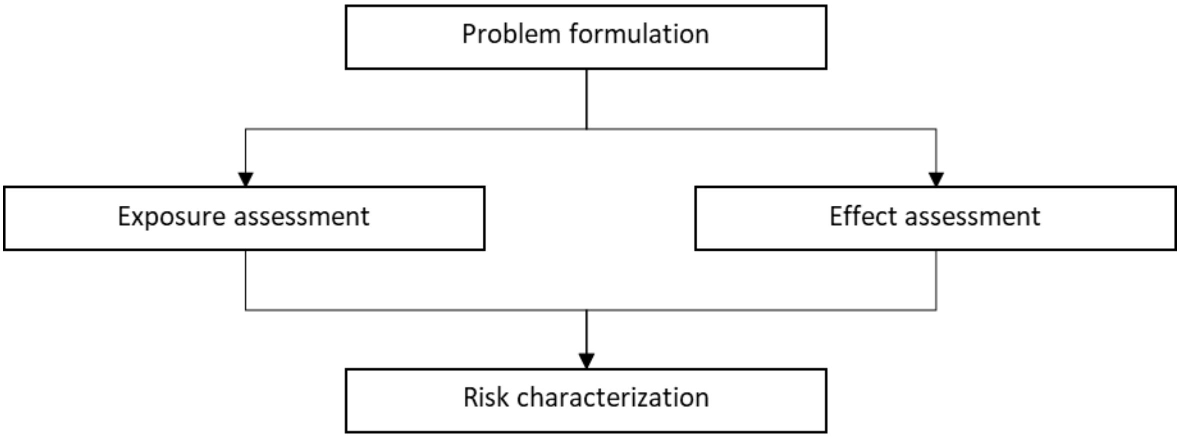

Figure 1:Key phases of ERA process

Problem formulation

Problem formulation is a key phase of any ERA process. On a broad level, the ERA process is driven by overall site management goals and regulations that set the expectations for the desired condition of the ecosystem and its components, in the context of future site use. In this phase, information about risk assessment goals, hazard sources, contaminants of concern (COC), and methodology for characterizing exposure and effects is collected for an explicitly stated problem. Environmental impacts from IOR/EOR solutions may be expected to occur in the marine environment due to produced water and drilling discharges and in the atmosphere due to increased emissions to air. The chemicals (tracers, polymers etc) used as a part of IOR solutions will be back produced with PW that needs to be discharged in the marine environment or re-injected in the reservoir. Therefore, the focus of the current ERA project is mainly on assessing the environmental risk due to PW discharges from IOR/EOR solutions.

Exposure assessment

The exposure assessment is a process of measuring or estimating the exposure in terms of intensity, space, and time in units that can be combined with effect assessment to characterize risk. A stressor is any substance or process that can have an adverse impact on the ecosystem. An example of a stressor in PW is toxic chemical present in the PW. The term predicted environmental concentration (PEC) is defined and calculated in the exposure assessment. PEC is the estimated chemical concentration in the environmental compartment that is calculated based on its environmental fate properties and amount discharged. From the context of PW discharges in the marine environment, a three-dimensional time-varying concentration distribution of chemicals in the PW is calculated by solving a generalised transport equation using the DREAM model (Reed and Hetland, 2002). Important variables in determining the fate of chemicals are the octanol-water coefficient and biodegradability, which are provided with input values in the DREAM model (Oslo and Paris Commission (OSPAR) guidelines, 2020). Other factors affecting the transport and concentration of chemicals in the marine environment are PW discharge volume, the concentration of a chemical in the PW, ocean currents, turbulence, discharge location etc. (Johnsen et al., 2000).

Effect assessment

The purpose of the effect assessment is to characterize the adverse effects of a stressor under an exposure condition to a receptor (here, marine organisms). A stressor in PW discharges is the toxicity of chemicals that are present in the PW. The adverse effects of a particular stressor on a receptor are usually measured by conducting acute/chronic toxicity tests in the laboratory. According to OSPAR guidelines, toxicity data for species from three trophic levels (standard species: algae, crustaceans, and fish) is usually required for risk assessments (ECHA R.10, 2008; OSPAR guidelines, 2020). The term predicted no-effect concentration (PNEC) is defined as the estimated concentration below which the adverse effect will most likely not occur in a receptor due to short- or long-term exposure of stressor. PNEC for any chemical compound is calculated using the lowest measured toxicity data and an appropriate assessment factor (ECHA R.10, 2008). An assessment factor is used to account for uncertainties such as extrapolation of toxicity data from the laboratory to field, from short-term toxicity data in the lab to actual chronic effects in the field, or from exposure to other species for which toxicity testing has not been done (Johnsen et al., 2000; ECHA R.10, 2008).

Risk characterization

Risk characterization is a process of estimating the magnitude of adverse environmental impacts based on the information collected from exposure and effects assessment. Risk characterization is done based on the PEC/PNEC ratio, which is also known as the risk characterization ratio (RCR) (Johnsen et al., 2000). If the RCR is found to be greater than 1, the chemical is considered to potentially pose a risk to the aquatic species. A set of PNEC values for naturally occurring chemical compounds in the PW is included in the DREAM model. The chemicals that are added for IOR/EOR purposes need to be tested for their ecotoxicological properties, mainly biodegradability, octanol-water coefficient, and toxicity (OSPAR, 2020). Once these parameters are measured, the chemical is added to the PW release profile and discharge is simulated using the DREAM model. The term environmental impact factor (EIF) is calculated by the DREAM model, which is the volume of water where RCR is greater than 1 for a given PW release to the marine environment. In the next section, firstly, the general ERA methodology that can be used for assessing environmental risk from IOR/EOR solutions is described. Thereafter, the method used in the current project to assess the environmental risk of specific IOR/EOR solutions such as tracer, polymers, and low salinity/polymer flooding is described.

Approaches to solve the IOR centres ERA issues

In this section, the approaches adopted in the current project to assess the environmental risk of different IOR solutions is explained. Firstly, a general ERA approach for field scale application of IOR solutions is described. This is followed by ERA of specific IOR solutions such as tracers, EOR polymers and low salinity/polymer flooding.

ERA in general field application

PW discharges are routine operational discharges from offshore oil and gas activities. The use of new chemicals such as tracers, polymers from IOR solutions will lead to their environmental release to the marine environment through produced water discharges. The risk of these new chemicals can be assessed by calculating their contribution to the EIF values estimated for a combined release of all chemicals using a DREAM model. For the implementation of EOR solutions, a need may arise for drilling new wells for smart water and/or polymer injection in the reservoir. A total of six stressors/effects are considered for drilling discharges in the DREAM model, two in the water column (concentration of toxic component and suspended particles) and four on the sediments (toxic component, oxygen depletion, change in grain size of sediments, and burial). Environmental impact due to these stressors in terms of EIF values is calculated using a DREAM model for drilling discharges (Singsaas et al, 2008). A detailed framework for assessing environmental risk from general field application of IOR solutions is published as an article (Vora et al, 2021).

ERA of tracers

The IOR centre has proposed seven inter-well partitioning tracer compounds that could be used for quantifying residual oil saturation. The basic ERA methodology for PW discharges discussed above and OSPAR guidelines form a basis for the ERA of tracers (OSPAR, 2020).

The knowledge of ecotoxicological properties such as biodegradability, toxicity and octanol-water coefficient are pre-requisite for assessing the environmental risk of any chemical (OSPAR, 2020). The biodegradability of tracers in the seawater was measured using a closed bottle method following OECD-306 test guidelines. Acute toxicity of tracers was measured in terms of per cent cell viability of rainbow trout fish gill cell line (RTgill-W1) and growth inhibition of the algae *skeletonema costatum*. Ecotoxicological information obtained from these experiments was used to create a profile for tracers in the DREAM model. The chemical composition data of PW from the Brage field on the NCS was used for simulating the release of PW in the marine environment. Each tracer compound was individually added to the PW release profile from the Brage field. The concentration of tracer in the PW release profile was varied to see the change in contribution to EIF at different concentrations. An article describing the experimental methodology used for measuring the biodegradability and toxicity of tracers along with the results of DREAM simulations for PW discharges with tracers is planned to be published.

ERA of EOR polymers

Injection of water-soluble EOR polymers is known to increase the oil recovery from reservoirs. The challenge with EOR polymers is their persistent nature to microbial degradation (Brakstad et al, 2020). From another project at the IOR Centre considerable new knowledge in terms of depolymerization rates (both due to biodegradation and ultraviolet (UV) degradation) and toxicity of polymers has been added. Currently, there is no standard methodology available that incorporates all the above parameters for calculating the residual time of polymers i.e. time taken by polymer for mineralisation. In this project, an attempt is made to combine the information available on depolymerization rate to calculate the residual time of polymers. DREAM model is used to calculate the concentration distribution of polymers at different time steps and locations in the marine environment. The concentration distribution data is then linked to the de-polymerization rate using Python programming to predict the residual time of polymers. Different scenarios for predicting residual time based on the concentration distribution from a single oil field and in case of simultaneous polymer discharged from all relevant oil fields on the NCS is studied. Data regarding relevant fields for polymer flooding on the NCS is made available by the Norwegian Petroleum Directorate (NPD). The planned approach is under an exploratory phase and if needed the information from other particle tracking models such as Opendrift will be included to aid the interpretation of the spreading of polymers in the marine environment on the NCS. Furthermore, the DREAM model is used to calculate the contribution to EIF values from EOR polymers. The PW release profile from the Brage field is used as a reference profile and EOR polymers are added to this profile to calculate the contribution to the EIF values. An article explaining the detailed methodology used and different scenarios considered to understand the fate and effects of EOR polymers in the marine environment is planned to be published.

ERA of smart water and polymer flooding

The ERA of smart water and polymer flooding is based on the data obtained from the adaptive ensemble-based production optimization method (in collaboration with the Production optimization project at the IOR Centre). The objective is to find the optimal strategy that maximizes a given reservoir performance index (objective function). Here, the objective function is a net present value (NPV) of all injected and produced fluids discounted from the total cash flow. The control strategy is a vector that includes constrained variables such as water injection rate, salt/polymer concentration (for smart water/polymer flooding), oil production rate or bottom hole pressure. A reactive and optimized case is defined, in a reactive case, a constant value for constrained variables is used throughout the simulation time whereas in the optimized case ensemble-based optimization method is used to maximize the objective function. A synthetic oil field Olympus is used for implementing the optimized and reactive cases and open porous media (OPM) is used to run reservoir simulation (Fonseca et al, 2018; Rasmussen et al, 2020). A detailed description of the ensemble-based optimization method is available from Oguntola and Lorentzen (2020).

In the ERA project, the objective is to understand the environmental risk related to PW discharges from smart water and polymer flooding. The data obtained from production optimization based on reactive and optimized cases is used for setting up simulations for PW discharges. The idea is to compare the EIF values for smart water and polymer flooding, both for the reactive and optimized case. This sort of comparison could help in understanding if the better EOR solutions from an economical perspective (optimized case) is also better from an environmental perspective. Furthermore, the EIF values for smart water and polymer flooding could be compared with the corresponding amount of oil recovery from these EOR processes. This type of comparison could clarify the EOR process that is more environmentally friendly in terms of oil recovery. An article explaining the detailed methodology used for ERA of low salinity and polymer flooding is planned to be published.

Guideline for practical ERA related to IOR solutions

Practical guidelines for conducting ERA of tracers

The environmental risk of the tracer compounds can be assessed based on the approach described above in the ERA of tracers. A produced water release profile containing all naturally occurring chemicals and production / other chemicals needs to be created in the DREAM model. Tracers can be added to the PW profile by using the biodegradability and toxicity data measured in the current project. The concentration of tracer measured in the PW needs to be included in the release profile along with the volume of PW discharged. Environmental risk in terms of contribution to the EIF values can be calculated for specific tracers using the DREAM model.

Practical guidelines for conducting ERA of EOR polymers

The two important aspects in ERA of EOR polymers are the fate and effects of EOR polymers after their release in the marine environment. Fate of polymers is estimated in terms of the residual time of EOR polymers. Effect of EOR polymers is calculated in terms of contribution to the EIF values using the DREAM model. The residual time of EOR polymers can be calculated by following the procedure mentioned below.

- The depolymerization rate of EOR polymer is found to be concentration dependent. DREAM model can be used to calculate the concentration distribution of EOR polymers after their release in the marine environment.
- From the output file of the DREAM simulation, the average and maximum concentration values of EOR polymers in the space at each time step can be calculated.
- The average and maximum concentration values can then be linked to the depolymerization rates to calculate the residual time of EOR polymers. The use of average and maximum values will cover the entire range of concentrations for calculating the residual time.
- A Python script for calculating the residual time taking into account the influence of different parameters such as concentration, UV intensity, composition and concentration of back produced polymers will be made available as a part of this project.

Furthermore, a considerable amount of toxicity data for different types of EOR polymer is available from another project at the IOR Centre and in the literature. Depending on the type of EOR polymer used in the oil field, relevant toxicity data can be used to create a component profile for EOR polymers in the DREAM model. Environmental risk in terms of EIF values for diverse concentration ranges can be calculated for different EOR polymers by following the procedure suggested for the ERA of tracers.

Practical guidelines for conducting ERA of low salinity and polymer flooding

The ERA of PW discharges from low salinity and polymer flooding can be conducted based on the approach described for the ERA of tracers and polymers. The main focus here is to compare how low salinity and polymer flooding fare against each other in terms of environmental risk (EIF values) and corresponding oil recovery. This is done by comparing the use of the production optimization method (developed at the IOR Centre) for optimum injection against the continuous injection of polymers. Optimum injection of polymers could result in lower concentrations of back produced polymer in the produced water compared to the continuous injection. Subsequently, the contribution to the EIF values will be less at lower concentrations compared to higher concentrations. Higher volumes of PW discharges result in higher EIF values. Therefore, the comparison could also be made for the volume of PW discharges from smart water and polymer flooding. Scenarios reflecting use of different EOR polymers in the injection and back production could be considered to evaluate the contribution to EIF values from different EOR polymers. Furthermore, scenarios based on re-injection of PW into the reservoir could be considered to evaluate the reduction in environmental risk due to re-injection.

Validation

The recommended practice validation process related to Environmental Risk Assessment of different IOR solutions can proceed through the following three steps:

Validation target	Validation action
a) Initial assumed ERA estimation method	> validation by testing with relevant basis data
b) Field-scale evaluation of ERA	> validation by testing basis data in combination with relevant full field-scale data
c) *In-situ* field evaluation of desktop estimated ERA	> validation by comparison of predicted environmental impacts with field measured environmental impacts

The different IOR solutions considered are given in the 'Introduction' (above), and the basic ERA methodology is described in the first paragraph of the 'Methods' chapter (above).

Initial assumed ERA estimation method

The first target for validation was to test if the currently used ERA methods and tools can be used to assess the environmental risk of different IOR solutions. This method's validity can be assessed by testing with relevant basis data and evaluating if the results are reasonable and as expected. Basis data here means data on environmental hazards, such as chemical toxicity, biodegradability, and bioaccumulation potential (OSPAR, 2020). The initially assumed ERA estimation methods are described in 'Approaches to solve the IOR center's ERA issues' (above).

In general, chemical discharges from IOR-related solutions will enter the sea as part of the produced water. This is the case both for natural constituents (e.g., hydrocarbons) and added chemicals.

ERA in general field application

Provided that there are basic ERA data available (OSPAR, 2020), the contribution of such chemicals to the environmental risk can be estimated by using the well-validated simulation tool (DREAM).

ERA of tracers

Regarding the tracers in focus, they were tested to obtain basis data at the IOR centre. Regular kind of values were obtained for all, and it can be considered that for other candidate tracer compounds that they can be tested by OSPAR methods and used in ERA estimates for produced water as long as they are of similar kinds as studied. In case of other types of emerging tracer chemical (e.g. nanoparticles) it is not validated through this testing that basic ERA data can be achieved by the standard methods.

ERA of EOR polymers

For EOR polymers, there is a lack of environmental basis data of the standard kind requested by OSPAR (2020). This is mainly due to the complex nature of the EOR polymer chemicals and the difficulties it makes for testing. In general, it is widely considered that these chemicals have fairly low toxicity but long degradation time, particularly due to low depolymerization rates. However, there are data found on toxicity and degradability, including residual depolymerization time to molecular sizes that are biodegradable, in recent literature and PhD work recently completed at the IOR Centre (Hansen et al, 2019; Farkas et al, 2020; Opsahl et al, *in subm.*2021, Opsahl & Kommedal *in subm.* 2021). A more thorough validation of how well the newly available basis data will work in combination with the initially assumed estimation method is still needed, and this validation work is presently ongoing at the IOR Centre.

ERA of smart water and polymer flooding

Except for the polymers that may represent similar challenges as the EOR polymers in the previous paragraph, the smart water constituents are not expected to contribute directly to the environmental risk. There may instead be an indirect increase in amounts of hydrocarbons in the produced water as a result of more efficient oil recovery. The oil constituent basis data are again part of the well-validated data for use in the simulation model DREAM and should not need any further validation.

Field-scale evaluation of ERA

The second target for validation was to test if basis data would perform adequately in combination with relevant full field-scale data.

ERA in general field application / ERA of tracers

This has so far been done by applying basis data described for validation target a) related to tracers in combination with full field-scale discharge data from the NCS. A general field application test case was set up based on full-scale data from the Brage field and assumed tracer discharge amounts combined with these were decided at the IOR Centre (IFE). It should be noted that the tracer data had no other connection with the Brage field than that it was chosen to provide an ERA field test case. However, regarded as a validation exercise, it provided results close to what was expected regarding contribution to the overall environmental risk. This work has recently been submitted for publication, including both laboratory test results and risk estimation by DREAM results (Vora et al., *subm.*).

ERA of EOR polymers

EOR polymers can at the moment due to the long depolymerization times cannot be used directly in the DREAM model to estimate their ERA contribution. Therefore, an additional model simulation is being developed with the aim to simulate the depolymerization dynamically in a way that makes it possible to combine with DREAM simulations, thus representing a validation of this combined methodological approach. This is presently ongoing work at the IOR Centre, and the conclusion is therefore pending.

ERA of smart water and polymer flooding.

This is, in our case, a combination of the ERA and ensemble-based optimization modeling as described in the 'Approaches…' chapter (above). The finalization of this work is pending on completion of a PhD thesis work, however for the reasons given under validation in a) (above), it is not expected that this will need further validation of going from basis ERA data to field-scale evaluation than what is already established for general use of the DREAM model to estimate IOR-contributions to environmental risk. A reservation might be for polymers with possible long residual times (see the previous paragraph). The interest in this field-scale case is not only the IOR-contributions to the overall environmental risk but also the possible change in environmental risk per recovered oil amounts. We assume this can simply be done by dividing the obtained EIF values by the recovered oil amounts at it will be tried out in the ongoing PhD-work with the ensemble-based case study.

In-situ field evaluation of desktop estimated ERA

This third validation step, which involves comparing predicted ERA with field measured ERA, is very difficult and costly to achieve. It will require field surveys with measurements of parameters that will reflect the key variables in the estimated environmental risks. This can technically be done by impact parameters in relation to a whole produced water discharge case (Brooks et al 2011; Sanni et al 2017), but it cannot at present be done on the IOR-contributions to the overall environmental impact and risk specifically. An exception may be in relation to a field where IOR-solutions have resulted in altered oil production and discharged oil amounts (as in the case of ERA of smart water and polymer flooding described in b) (above) or even as a reduction of oil discharged due to IOR-related PW injection. In such a case, this change could be field validated through the kind of monitoring that is being regularly done on the NCS, for instance, as it has previously been conducted to validate that the discharge impacts had been reduced by implementing the PW cleaning system Ctour on Ekofisk.

Conclusion and recommendations

A general conclusion is that existing laboratory test methods and environmental risk models can largely be applied to assess the environmental risk in the IOR-related solutions focused on at the IOR Centre and it is our recommendation to use these methods according to the practical descriptions in this report. There are some important exceptions where there are knowledge gaps for which we hope that the ongoing PhD work will be clarifying to provide approaches and procedures. Therefore, the conclusions related to such cases are not finalized in this recommended practice report. Regardless of the pending PhD work in our project we have identified that there will still be knowledge gaps related to the toxicity of different types and sizes of EoR polymers. Additionally, it has been identified that the EoR polymers may undergo hydrolysis once discharged in the marine environment (Opsahl et al., 2022). The hydrolysis of EoR polymers accelerates the de-polymerization process, however, the rate of hydrolysis remains to be measured and to be included in the residual time calculations of different EoR polymers. Furthermore, for ERA of smart water and polymer flooding in collaboration with the production optimization project at the IOR Centre, additional scenarios could be defined to assess the economic benefits and environmental risks of different IOR solutions (smart water/polymer) on the NCS. This type of analysis could be helpful in supporting the decision making to maintain a balance between the economic benefits and environmental impacts.

The way forward is that depending on the pending clarifications, it will hopefully be possible to estimate the environmental impacts and economic benefits of alternative production strategies for improved overall field management. Further dependent on the pending clarifications it will hopefully also be possible to perform a larger regional evaluation of the potential environmental impact/risk of full scale IOR-application, which may be done based on the ERA methods tested/developed at the IOR Centre combined with compiled data from the Norwegian Continental Shelf. These achievements would contribute strongly to the usefulness and impact value of the recommended practices presented for ERA of IOR solutions.

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