



OPEN Optimization of salinity and composition of injected low salinity water into sandstone reservoirs with minimum scale deposition

Masoud Bijani¹, Ehsan Khamnehchi^{1,2} & Mehdi Shabani²

In this study, a mechanistic and comprehensive examination of the impact of the scale formation situation of different diluted seawater levels was conducted to investigate the influence of important factors on the performance and efficiency of low salinity water. To clarify the effective participating mechanisms, scale precipitation by compatibility test, field emission scanning electron microscopy (FESEM) and energy dispersive X-ray spectroscopy (EDX) analysis, zeta potentials as surface charge, ion concentration changes, contact angle, pH, CO_3 concentration, electrical conductivity, and ionic strength were analyzed. The results showed that increasing the dilution time to the optimal level (10 times-diluted seawater (SW#10D)) could effectively reduce the amount of severe precipitation of calcium carbonate (CaCO_3) and calcium sulfate (CaSO_4) scales. However, the reduction in CaCO_3 scale precipitation (due to mixing different time diluted seawater with formation brine) and its effect on the wettability alteration (due to the change in surface charge of OLSW/oil and sandstone/OLSW) had higher impacts. The zeta potential results have shown that OLSW with optimum salinity, dilution, and ionic composition compared to different low salinity water compositions could change the surface charge of OLSW/oil/rock (~ 16.7 mV) and OLSW/rock (~ 10.5 mV) interfaces toward an extra negatively charged. FESEM and contact angle findings confirmed zeta potential results, i.e. OLSW was able to make sandstone surface more negative with diluting seawater and wettability changes from oil-wet toward water-wet. As a result, SW#10D was characterized by minimum scaling tendency and scale deposition (60 mg/l), maximum surface charge of OLSW/oil/rock (~ 16.7 mV), and the potential of incremental oil recovery due to wettability alteration toward more water-wetness (the oil/rock contact angle $\sim 50.13^\circ$) compared with other diluted seawater levels.

Fossil fuels are a significant portion of the worldwide energy supply¹. One of the oldest and well-known methods used in oil reservoirs for pressure maintenance and improved oil recovery is water injection. Water injection is the most considerably applied increased oil recovery method after the natural recovery of oil reservoirs². Lately, low salinity water injection (LSWI) and smart water injection (SWI) showed positive effects in the recovery factor of oil reservoirs³. Various laboratory experiments and field applications have shown increasing oil production because of modification of ion amount or reducing salinity level of seawater and increasing the dilution ratio of seawater^{4–11}. LSWI and SWI can be applied as improved oil production methods after changing the wettability of oil reservoirs^{12–16}. The prominent mechanisms of LSW flooding were wettability alteration, fine migration, rock dissolution, multiple ion exchange (MIE), and double layer expansion^{17,18}. Though, the dominant mechanism is referenced as wettability alteration in literature^{14,19}. Smart water as a kind of injection water can have two meanings under different definitions as follows^{19–21}:

- Application of saline water at low concentrations, neglecting the type of ions.
- Synthesis of a new water composition according to ion design considering their concentration and type.

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Salinity In Watercourses Reservoirs

Shaik Feroz, Detlef W. Bahnemann



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Salinity in Watercourses and Reservoirs Richard H. French, 1984

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Using Desalination Technologies for Water Treatment ,1988

Colorado River Ecology and Dam Management National Research

Council, Division on Earth and Life Studies, Commission on Geosciences, Environment and Resources, Water Science and Technology Board, Committee to Review the Glen Canyon Environmental Studies, 1991-02-01 This book contains 11 papers that review the extant information about the Colorado River from an ecosystem perspective and serve as the basis for discussion of the use of ecosystem earth science information for river management and dam operations It also contains a synopsis of the committee's findings and recommendations to the Bureau of Reclamation as the agency seeks to change its direction to the management of natural resources

Salt Water Intrusion Samuel F. Atkinson, 2018-01-18 This book provides a summary of the status and potential for salt water intrusion into ground water in the contiguous United States While the focus is on resultant limitation in the agricultural usage of ground water the book is not limited to this singular limitation in resource usage

Removal of Pollutants from Saline Water Shaik Feroz, Detlef W. Bahnemann, 2021-12-22 Removal of Pollutants from Saline Water Treatment Technologies provides a comprehensive understanding of technologies that are currently adopted in the treatment of pollutants present in saline water systems It provides information on the treatment technologies for saline water systems including seawater brackish water oil produced water and other industrial saline wastewaters FEATURES Presents information exclusively for saline water pollutant removal Introduces current treatment technologies and addresses why and how the techniques differ between fresh and salt water Offers an inclusive overview of physicochemical biological membrane and advanced oxidation treatment technologies Features various perspectives and case studies from relevant global experts Provides a comprehensive one stop source for the treatment of pollutants in all saline water systems Aimed at students academicians researchers and practicing engineers in the fields of chemical civil marine and environmental engineering who wish to be acquainted with the most recent developments in the treatment of pollutants present in saline water systems Prof Dr Shaik Feroz works at Prince Mohammad Bin Fahd University Kingdom of Saudi Arabia He has 30 years of experience in teaching research and industry He has more than 190 publications to his credit in journals and conferences of international repute He was awarded Best Researcher by Caledonian College of Engineering for the year 2014 Prof Dr Detlef W Bahnemann is Head of the Research Unit Photocatalysis and Nanotechnology at Leibniz University Hannover Germany Director of the Research Institute Nanocomposite Materials for Photonic Applications at Saint Petersburg State University Russian Federation and Distinguished Professor at Shaanxi University of Science and Technology in Xi'an People's Republic of China His research topics include photocatalysis photoelectrochemistry solar chemistry and photochemistry focused on synthesis and physical chemical properties of semiconductor and metal

nanoparticles His 500 plus publications have been cited more than 65 000 times h index 100 Quality of Water Resources in Poland Martina Zelenáková, Katarzyna Kubiak-Wójcicka, Abdelazim M Negm, 2021-02-18 This book presents state of the art knowledge concerning water quality in Poland It offers a wide variety of cases and issues on water resource quality management The book also presents different methods and strategies to effectively use the most advanced water resource quality problems such as water pollution whether physical chemical or biological of surface water resources and groundwater resources The authors pay exceptional attention to water quality monitoring in agricultural urban catchments and water reservoirs More light into the water quality is required to assess water s physicochemical status accurately and plan suitable protection actions against recognized threats This book addresses the needs of professional engineers researchers policy planners decision makers stakeholders and anyone looking to learn more about the quality situation of water resources in Poland and other similar countries and regions Water Resource Management Issues Louis Theodore, R. Ryan Dupont, 2019-11-26 Drinking Water Safety Basic Principles and Applications examines the technical and scientific as well as regulatory ethical and emerging issues of pollution prevention sustainability and optimization for the production and management of safe drinking water to cope with environmental pollution population growth increasing demand terrorist threats and climate change pressures It presents a summary of conventional water and wastewater treatment technologies in addition to the latest processes Features include Provides a summary of current and future of global water resources and availability Summarizes key U S regulatory programs designed to ensure protection of water quality and safe drinking water supplies with details on modern approaches for water utility resilience Examines the latest water treatment technologies and processes including separate chapters on evaporation crystallization nanotechnology membrane based processes and innovative desalination approaches Reviews the specialized literature on pollution prevention sustainability and the role of optimization in water treatment and related areas as well as references for further reading Provides illustrative examples and case studies that complement the text throughout as well as an appendix with sections on units and conversion constants **Proceedings of the National Conference on Water Resources Research**, 1985 *Tropical Freshwater Wetlands* H. Roggeri, 2013-03-09 Wetlands could be described as land and water at Tropical wetlands one and the same time and as such are very specific on the brink ecosystems Their often rich variety of resources makes them highly valuable to the peoples who live With a few exceptions like the Everglades in the or regularly stay in them However access to them United States the last remaining large wetlands are to be found in developing countries Perhaps this can is difficult and those unaware of their services be explained by insufficient financial resources frequently associate wetlands with such nuisances and calamities as mosquitos disease floods impen lower popUlation density or a different concept of etrable wastelands etc As a result these areas are development and well being Whatever the reasons often perceived as obstacles to human development many tropical wetlands still exist and support the and well being subsistence

of many communities But for how much History reflects these two views Wetlands may longer have been the cradle of great civilizations like the During the last few decades tropical wetlands Maya Inca Aztec Nilotic and Mesopotamian have also been destroyed or considerably altered Dams and embankments now prevent water from civilizations but elsewhere their destruction allowed other societies to develop For example the Nether spreading into the floodplains of several rivers like lands literally emerged from the waters thanks to the Senegal Volta and Nile **Rivers of the United States, Volume V**

Part A Ruth Patrick,2000-04-10 The six volume of Rivers of the United States provides an integrated and comprehensive examination of all the major rivers and estuaries of the contiguous United States This fifth volume the first of two parts is concerned with the Colorado River Tampa Bay Regional Reservoir Project ,2001 **U.S. Geological Survey**
Water-supply Paper ,1982 **Water Resources System Operation** Vijay P. Singh,Ram Narayan Yadava,2003

Geology of Iraq Saad Z. Jassim,Jeremy C. Goff,2006 This book is written by 16 experienced geologists with first hand knowledge of the geology of Iraq and deals with all aspects of the country s geology The aims of the book are to present a synthesis of the geological history of Iraq and a description of its economic geology and to provide a key reference for both students and professional geologists It updates the text books of Buday 1980 and Buday and Jassim 1987 The book includes previously unpublished information collected during the regional geological surveys of Iraq carried out from 1970 to 1990 Each chapter has been extensively edited to create a concise text The stratigraphy of Iraq is placed within a consistent tectonostratigraphic framework The Ocean and Cryosphere in a Changing Climate Intergovernmental Panel on Climate Change (IPCC),2022-05-19 The Intergovernmental Panel on Climate Change IPCC is the leading international body for assessing the science related to climate change It provides policymakers with regular assessments of the scientific basis of human induced climate change its impacts and future risks and options for adaptation and mitigation This IPCC Special Report on the Ocean and Cryosphere in a Changing Climate is the most comprehensive and up to date assessment of the observed and projected changes to the ocean and cryosphere and their associated impacts and risks with a focus on resilience risk management response options and adaptation measures considering both their potential and limitations It brings together knowledge on physical and biogeochemical changes the interplay with ecosystem changes and the implications for human communities It serves policymakers decision makers stakeholders and all interested parties with unbiased up to date policy relevant information This title is also available as Open Access on Cambridge Core Planning Guide for Evaluating Agricultural Nonpoint Source Water Quality Controls Paul D. Robillard,Michael F. Walter,Linda M. Bruckner,1982 **Wild and Scenic River Suitability Study for National Forest System Lands in Utah** ,2008

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