Management alternatives

Underground injection

Different management alternatives can be used for shale gas wastewater to reduce socioeconomic, health and environmental risks. It is estimated that around 95% of the shale gas wastewater produced in the U.S. is currently disposed in Class II saline water wells through conventional underground injection (4). Although deep-well injection still remains as the dominant practice mainly due to economic reasons, factors associated with capacity constraints, potential groundwater contamination, and induced seismic activity have recently arisen as driving forces for the application of advanced wastewater managing strategies.

Internal water reuse

Water reuse in internal shale gas operations is another beneficial alternative for the pretreatment and desalination of high-salinity shale gas wastewater—operations usually demand excessive freshwater consumption and generate large wastewater volumes (5). Aside from chemical additives present in hydrotreating fluids, wastewater is also composed by the shale formation constituents, which can include organic matter, naturally occurring radioactive materials (NORM), salts and scale-forming ions (3). The highly polluting nature of shale gas wastewater impels the application of energy-intensive pretreatment and desalination, to allow water reuse in hydraulic fracturing processes, water recycling or safe disposal. This work aims to offer an overview of main challenges and perspectives of alternatives for water reuse and recycling in shale gas wastewater management.

Challenges of ZLD desalination

ZLD desalination systems can be composed by thermal and/or membrane-based technologies. While thermal evaporation processes—such as single/multiple-effect evaporation coupled to mechanical vapor compression (SEEME-MVC) (9)—are already relatively well-established processes in the industry, membrane-based systems—including membrane distillation (MD), forward osmosis (FO), nanofiltration (NF), reverse osmosis (RO), and electrodialysis/electrodialysis-reversal (ED-EDR)—have recently emerged as appealing alternatives for high-salinity wastewater applications.

Environmental impacts

As both thermal and electrical used to power membrane desalination systems are generally produced from non-renewable carbon sources, the carbon footprint of ZLD operation is accountable for important polluting GHG emissions to the environment. In ZLD systems, the carbon footprint can be directly related to the use of thermal sources (typically steam), or indirectly to energy consumption from electric energy grids. Associated potential environmental impacts can be managed by the development of thermal and membrane technologies with higher energy and water recovery efficiencies, as well as through the incorporation of low-grade heat and renewable energy sources.

Overview and perspectives

Although water reuse has attracted increased interest as a wastewater management strategy for enhancing water efficiency in shale gas activity, this alternative is limited by the demand of the industry expansion. As water reuse is not a sustainable long-term solution, wastewater desalination should be considered to allow water recycling or even safe disposal. ZLD systems emerge as an appealing solution to face the need to address water sustainability concerns, while accounting for environmental impacts related to shale gas wastewater and brine releases. However, energy consumption and GHG emissions, and specific operational problems (tailing and scaling), are major challenges for the further development and implementation of emerging ZLD desalination technologies. Former environmental regulations on brine discharges and water quality, and regulatory incentives will eventually guide this project's development.

Acknowledgements

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 640979.

The financial support provided by the European Regional Development Fund (FEDER), Regional Operational Program of the Center (CENTRO2020), grant No. CENTRO-01-0145-FEDER-000006, and the Portuguese Foundation for Science and Technology (FCT), grant No. UID/MULTI/00389/2013 are also acknowledged.

References