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RESEARCH ARTICLE

Feasible analysis of reusing flowback produced water in the operational performances of oil reservoirs

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Abstract
Water reuse is considered one of the most efficient and optimum ways in petroleum industries to address the water scarcity problem. The effluents which are made by the petroleum operations are supposed to be one of the hazardous materials when they are discharged to the environment. The objective of this study is to measure the volume of the required water for the operational performances of the studied oil field. To do this, the necessary water and the volume of provided treated water for the waterflooding, tertiary flooding, and hydraulic fracturing procedures are appropriately measured and by the utilization of photo-Fenton/flotation are administered to remove the oil droplets. According to the observational measurements, it is clarified that hydraulic fracturing has supplied approximately 93% of its required water by the treatment of flowback water and it virtually eliminated the necessity of fresh water from local or domestic water resources. Moreover, the total freshwater that has been saved in this oil field is investigated about 80% of the total required water for their performances. Consequently, the lower need of fresh water from local resources would reduce the unnecessary expenses to provide this volume of water and would save fresh water for about 2750 inhabitants for 1 year to overcome the issue of water scarcity in the world.

Keywords Flowback water · Water scarcity · Hydraulic fracturing procedures · Water resources · Environment

Introduction

A proper estimation schedule should be prepared accurately to espouse the importance of water reuse in the long-term sustainable purposes (Bagheri et al. 2018; Chen et al. 2018; Da Cunha et al. 2006; de Abreu Domingos and da Fonseca 2018; DiGiulio and Jackson 2016). Most of the consumed water in industries are being elaborated as petroleum and drilling industries, petrochemical industries which are used the water for most of their processes and operational activities, and other different applications of water like agricultural procedures. Hence, it is required to enhance the novel strategies of reusing wastewater to address the problem of water scarcity. In petrochemical operational sites, water has performed as the primary resource for each production and operational processes. These processes entailed washing performances of equipment and hydraulic devices, distillation procedures in processing towers, the extraction process of two-phase fluid (especially liquid-liquid phase) (Davarpanah 2018a, b), and cooling operations which are in urgent need of water supplies to be performed as the major requirements in the petrochemical industries. Among the total volume of water consumption throughout the world, industrial performances have allocated about 1/5 of this amount and would be the most significant consumer in the future regarding the daily increase of water in their operations (Bai et al. 2013; Barrington et al. 2013; Garg et al. 2017; Gilbert and Moore 2005). According to Hansen et al. (2018), the clarity and filtration of consumed water in a petrochemical site was conducted into the investigation, and the proposed water integration system would reduce the water demand approximately 600 l per each of petrochemical materials. It is of elaborated that the determination of proper agreement criteria for the obtaining the optimum volume of wastewater administration in the chemical processes which is statistically illustrated that the reusing alternatives had saved relatively 20% of fresh water and 27% of wastewater that is produced from each stage in chemical procedures. Therefore, this volume of water saving would provide about 4626 people's water consumption for 1 year and subsequently

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this reduction is virtually eliminated the vast operational expenditures of chemical reactions and transferring of water from local water resources (É. Hansen et al. 2018). Furthermore, Hansen et al. (2016), proposed the new recycling system for the water reuse in a cascade schema in one of the petrochemical sites of Brazil to validate an appropriate method of less demand to the local water supplies. To operate this model, it is concentrated on the aqueous streams to remediate the occurred losses in the system which is based on the heuristic approach on the process cycle. Working procedure of this method contained the proper processing map construction which is identified the stages of consumed water and the produced water volume due to the consideration of aqueous streams in the designation of the process cycle. Thereby, it is significantly demonstrated that the utilization of this model had implemented the total of saving water about 385,440 cubic meters per annual that would provide the water consumption of 6350 people for 1 year (E. Hansen et al. 2016). Another paramount industry which has the highest volume of water consumption in their operational circumstances is the petroleum industry, especially in drilling and exploration processes. In the exploration performances of hydrocarbon reservoirs, the vast volume of wastewater would be generated in the surface which is considered as the significant sources of water supply for the sequential operations that are in urgent need of water to continue the procedures like hydraulic fracturing (Quartaroli et al. 2017; Smith et al. 2018; Thacker et al. 2015; Zheng et al. 2006; Zolfaghari et al. 2016). Hydraulic fracturing is one of the major operations in exploration procedures of gas and oil wells and its hazardous effects on the environment regarding the acquisition of water and the existence pollutant materials in the formation has potentially debated by researchers and petroleum industries (DiGiulio and Jackson 2016; Gallegos et al. 2015; Nicot and Scanlon 2012; Simonsen et al. 2018; Smith et al. 2018; Vengosh et al. 2014; Vidic et al. 2013). According to the Oetjen et al. (2018) for a successful and proper fracturing process, relatively 20,000 m^3 of water might be required which may be provided from local freshwater resources or wastewater which is produced during the production operations. In respect of the way, after the completion of hydraulic fracturing performances, the administered water was returned to the surface as wastewater which is called flowback. At the beginning stages of produced water in the surface, the flowback water is more sounded as the representative of injection water in the shallower depths. By passing the water production time, the produced water is combined with the non-pure materials which is entered from the oil and gas formation that might alter some of the rheological characteristics of the water (Bai et al. 2013; Da Cunha et al. 2006; da Silva et al. 2015; Hassani et al. 2017; Jafarinejad 2017; Olmstead 2015; Thacker et al. 2015). To reuse the produced wastewater in the surface, proper complex chemical operations should be performed to distinguish the inorganic and organic materials adequately. Subsequently, it has been treated again in the processes. Other uses of water in drilling operations is related to cool the equipment like drilling bit during the mud circulation phenomenon (Hagström et al. 2016; Hawthorne et al. 2014; Huang et al. 2018; Javadpour et al. 2015; Jin et al. 2017; Murali Mohan et al. 2013; Smith et al. 2018). Regarding the complexities of wastewater treatment and its vast expenditures, the proper utilization of wastewater and estimate its adequate volume should be taken into consideration before injection. As an example, in the USA, approximately 97% of produced water is reinjected to the exploration wells for several purposes like fracturing, pressure maintenance, and also for disposal wells (Clark and Veil 2009). Although the wastewater has virtually eliminated the urgent requirement of local freshwater resources, the environment is exposed to the hazardous materials and unsolved solids which have exercised a detrimental impact. Numerous laboratory investigations and research proposals are concentrated on the quality and quantity of reusing water in petroleum industries which most of them are used as the spatial and specific approach in several oil fields. Some of the typical limitations and significant concerns in the utilization of wastewater are as follows:

- The health issue which is encountered by people or staffs is exposed to the nearest locations of an exploration well.
- Some of the untreated materials in the flowback water such as total dissolved solids (TDS) and hazardous constituents that might not be removed after treatment which have a severe impact on the environment.
- Risk assessment of transmission and handling of flowback water to the water integration system which is not efficiently evaluated.
- To be ensured that the treated water would be appropriately monitored to obtain the ultimate volume of reused water (Barbot et al. 2013; Khan et al. 2016; Luek and Gonsior 2017; Luek et al. 2017; Monzon et al. 2017; Thacker et al. 2015; Vengosh et al. 2014; Wunsch et al. 2013)

Oil and gas components are being extracted from different ways in the petroleum wells in the forms of water, gas, solid, and oil composites. In the petroleum and gas industries, the production of oil and gas are being operated due to the gravitational forces which are based on the horizontal, vertical, and spherical separators. One of the major techniques to separate the current fluid phase such as oil, gas, and water is the utilization of horizontal separator to separate the fluid phases. According to the Euler-model, the behavior of two phases is explicitly illustrated to define the separation efficiencies in different velocities in the outlet. Moreover, the distance of the diverter plate and the inlet are being calculated appropriately. Yayla et al. (2017) proposed an analytical model to design a three-dimensional horizontal separator for the division of two-phase flow in the steady-state condition. In their model, the considerable influence of inlet velocity of the mixture and the distance of diverter plate and the inlet are mathematically modeled. To validate the proposed model, different data categories are being simulated by computational fluid dynamics (CFD) technique which is depicted that there is a direct proportion between the separation efficiency and the distance. On the other hand, according to their findings, there is an inverse relation with the separation efficiency and the velocity of the inlet (Yayla et al. 2017).

This comprehensive study elaborated the experimental evaluation of gas and oil wells that are drilled by the hydraulic fracturing procedures in one of Iranian's oil field units, Cheshmeh-Khosh oil field unit which is located in the south of Iran. In respect of the way, this oil field's formation is constructed mainly from Sarvak and Asmari formation. To do this, adequate measurement of injected water for several purposes such as hydraulic fracturing, cooling, and lubrication system, water volume which is needed for enhanced oil recovery processes, and appropriate treatment of flowback wastewater are significantly monitored. According to the experimental investigations for the studied wells in this oilfield, the primary purpose of this study is to measure the approximate volume of fresh water and wastewater which is provided by inorganic and organic treatment and subsequently how much fresh water would be saved per annual. Furthermore, the treatment model based on the integration of floatation and photo-Fenton are being developed to eliminate the oil droplets in the returned water which is treated in the separation processes.

Methodology

Rock and reservoir properties of the studied oil field

Due to the construction of the studied oil field from different formations, the reservoir characteristics are reported in the average value to be more accurate. To estimate the most appropriate value for the porosity, some ways are widely reported in the literature which includes direct techniques and indirect techniques. The former entails the use of core analysis which is extracted from the rock formation during the drilling operation, X-ray computerized tomography scans, scanning electron microscope examination, and nuclear magnetic resonance (NMR) spectroscopy techniques. The latter include those techniques that the laboratory measurement and economic prosperity to provide core analysis are not feasible. Moreover, the utilization of production logging tools in the coming decades would be considered as a proper selection for estimating permeability. Therefore, the average porosity that is measured from neutron logs is relatively 4.87–8.64% which has varied for each layer; the permeability alterations for this oil field is about 3.54 mD for gas shale layers and 11.89 mD for oil shale layers that has higher permeable layers than gas shale layers. Also, the connate water saturation, original oil in place, gas cap volume was estimated at 0.1, 1026.15 MMMSTB and 14.25 MMMSCF respectively. In this oilfield, regarding the small thickness of layers and higher conductivity between the reservoir and the well, horizontal drilling would be more suggested to obtain more volume of hydrocarbon fluids in the surface. There are ten exploration wells that were being drilled from the year 2001 which six of them are in the oil shale layer, three of them are in the gas shale layer, and one of the wells was drilled by the purpose of transferring the disposal materials such as solid particles and poisonous materials which are separated in separation units (Davarpanah et al. 2018; Mazarei et al. n.d.; Rabbani et al. 2018).

Oil field operational performances

Operational performances are entailed oil production, gas production, water production, and water cut fraction which is statistically demonstrated in Table 1. Due to the passing time of production for each well, the instantaneous volume for each parameter has decreased slightly. Hence, we consider the average value for these parameters per annual to grasp the importance of each parameter more adequately. As can be seen in Table 1, oil wells regarding their high potential of containing more oil volume have higher oil production rate because in gas wells only gas has produced on the surface.

Table 1 Operational performances of studied oil field

Well no./parameter	Average oil production rate per year (MMSTB/day)	Average gas production rate per year (MMSCF/day)	Average water production rate per year (MMSTB/day)	Average water cut fraction per year (percent)
Well-OW-01	164.21	15.74	30.34	0.084
Well-OW*-02	156.32	16.89	27.41	0.076
Well-OW-03	142.17	17.34	24.35	0.071
Well-OW-04	134.85	22.71	21.42	0.068
Well-OW-05	152.17	25.36	26.84	0.081
Well-OW-06	126.74	14.32	19.74	0.059
Well-GW*-01	0	70.52	21.43	0.023
Well-GW-02	0	86.34	20.86	0.0198
Well-GW-03	0	78.19	18.54	0.0168

*OW and GW are the representatives of oil wells and gas wells

Integrated systems for produced water treatment in oil field units

The flowback water which is produced in the surface is one of the principal challenges of petroleum industries as the waste streams, and drilling industries push themselves into limits to utilize the most substantial proportion of treated water in their operations to achieve a massive volume of oil and gas production rates. The procedure of the water treatment system is schematically depicted in Fig. 1.

The treatment of produced water entailed chemical, physical, membrane treatment, and biological techniques which are explicitly reported in the literature by Fakhru'l-Razi et al. (2009). They concentrated on the various types of filtration, chemical oxidation, activated carbon, air strippers, steam strippers, evaporation, and osmosis reverse activities which have played a substantial role in the treatment of flowback water (Adham et al. 2018; Aghdasinia and Farahani 2010; Fakhru'l-Razi et al. 2009; Golestanbagh et al. 2016). Physical techniques due to their adverse effects on the environment is not recommended and chemical methods regarding their vast expenditures are not preferred for the removal of oily droplets from flowback water (Fakhru'l-Razi et al. 2010; Luek et al. 2017; Monzon et al. 2017; Pendashteh et al. 2012). The appropriate administration of water treatment systems gives the drilling staffs the chance to handle the procedures adequately (Hagström et al. 2016). For example, according to the da Silva et al. (2015) evaluations on the flotation and photo-Fenton methods on the removal of approximately 99% of oil droplets in 10 min flotation which is followed by the rotation of 45 min of photo-Fenton (da Silva et al. 2015).

Furthermore, Yayla et al. (2017) proposed a 2D dynamic model for the coalesced plates to analyze the Reynolds number and further influence of hole shape of the plate on the efficiency of separation techniques. According to their findings, a cylindrical hole shape with the diameter of 15 mm on the coalesced beds had provided the most considerable efficiency for separation techniques. Hence, the fraction of oil had altered from 5% to 15% which improved the efficiency to about 30% (Yayla et al. 2017). Also, according to the numerous studies which have been done on the biological treatment of floback water by the utilization of salt-tolerant microorganism which indicated that due to the salt concentration increase, the organic pollutants removal efficiency had decreased drastically (Fakhru'l-Razi et al. 2010; Monzon et al. 2017; Pendashteh et al. 2012). As it is evident in Fig. 2, the flowback water has encountered into a multi-stage process in every stage has designed to separate specific material such as solid control separation, salinity removal, and oil and gas which are in liquid/gas phase from the system. One of the significant parts of separation methods is related to the oil droplet removal. Therefore, in this study, to eliminate the oil droplets from the flow-back water in the first stages of separation, the combination of photo-Fenton and flotation were implemented. To perform a balance between the water entrance and the separation close loop system, various level indicators were put in each stage and, finally, the total volume of treated water was measured according to the mass balance equation to check the validity and accuracy of the proposed water integration system and subsequently calculate the efficiency of the model.

Results and discussion

Required water measurement for enhanced oil recovery techniques

The production of hydrocarbon fossil fuels such as oil and gas are divided into three different stages; primary oil recovery

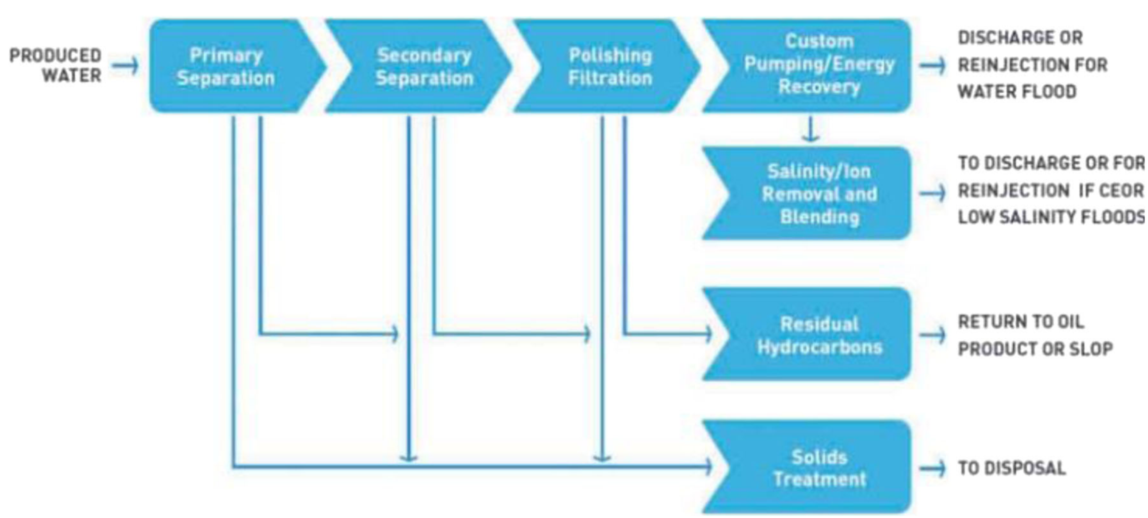

Fig. 1 Schematic of water treatment procedures (Golestanbagh et al. 2016)

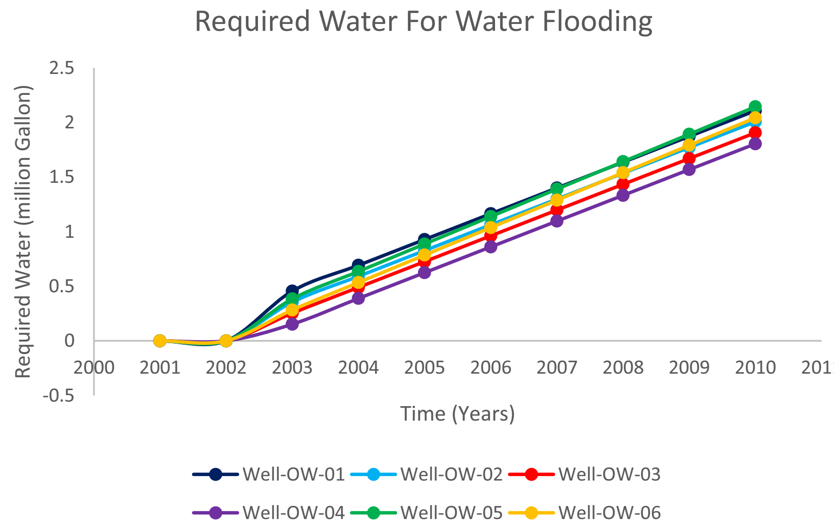

Fig. 2 Required water for waterflooding

techniques are based on the natural depletion drive mechanisms that they did not need any specific pushing drive to mobilize the hydrocarbons to the surface. When the natural drives could not be able to pull forward the hydrocarbon to the surface, secondary and tertiary techniques were performed to produce and stabilize the production rate, and subsequently, it is preferably economical. Among different types of secondary enhanced recovery techniques, waterflooding was considered as the optimum technique in shale layers regarding the high potential of water in these layers. As can be seen in Fig. 2, the waterflooding had started after 2 years of production with natural depletion drive due to the drilling six oil wells to produce more oil volume. That is to say that regarding the passing the time of water injection, the volume of required water is dramatically increased and, therefore, in the year of 2010, waterflooding was not considered as the optimal methods, and it is a sense of urgency to applied tertiary techniques like polymer flooding which is required water for the recovery processes.

Thereby, providing these large volumes of required water for waterflooding might not be economically profitable, and petroleum industries try to treat flowback water to be reused in the waterflooding performances. The total volume of water which is needed during the years 2003–2010 is statistically explained in Table 2. As it is evident, approximately 67–85% of fresh water had saved entirely in the studied oil field, and thereby, about 40 million gallons of freshwater are saved during the injectivity procedures which provided the water resources for 4560 inhabitants per year. Consequently, smaller freshwater volume resources would be required for this oil field and it would virtually eliminate the vast expenses of transferring water to the oilfield, and it further helps the problem of water scarcity.

Required water measurement for polymer flooding procedure

Among different types of tertiary enhanced recovery techniques, polymer flooding was considered as the optimum technique in shale layers regarding the high potential of water in these layers. To perform the polymer flooding processes in the reservoir when the mobility ratio of flooded water is large enough, polymers with the high viscosity and the molecular weight is added to the water to reduce the flooding water mobility which is caused to improve the sweep efficiency. As can be seen in Fig. 3, the polymer flooding had started from 2010 to 2015, and the volume of required water is dramatically increased. The required water volume for the polymer flooding is measured according to the following steps:

(1) The required water for water flooding in the first stages of recovery techniques differed for each well.
(2) After the addition of polymer to control the water mobility ratio, this water volume has been increased by passing

Table 2 Total required water and wastewater for waterflooding after treatment from 2003 to 2010

Well no.	Total required water (MM gallon)	Total provided wastewater after treatment (MM gallon)	Total fresh water (MM gallon)	Fresh water savings (%)
Well-OW-01	10.26	7.33	2.93	70.73
Well-OW-02	9.45	6.47	2.98	70.21
Well-OW-03	8.64	6.52	2.12	78.81
Well-OW-04	7.83	6.38	1.45	85.49
Well-OW-05	10.11	7.43	2.68	73.16
Well-OW-06	9.30	6.06	3.24	67.58
Total	55.58	40.18	15.40	–

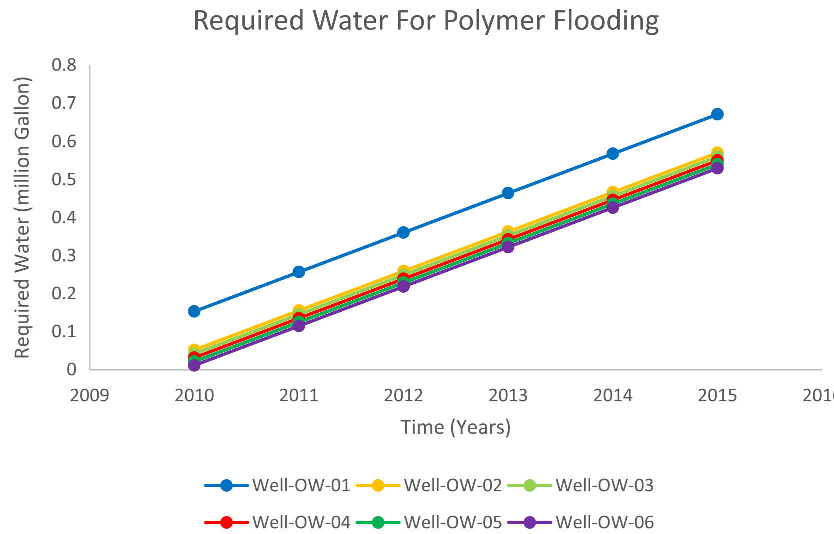

Fig. 3 Required water for polymer flooding

the production time regarding the thickening property of the polymer particles.

Moreover, as it is evident in Fig. 3, due to the addition of polymer particles to the flooded water, the volume of required water to improve the microscopic displacement in the reservoir had been increased drastically which caused to administer vast expenditures for drilling the wells in this field. Therefore, in the year of 2015, polymer flooding technique is not as efficient as its performance in the beginning years because the reservoir is in urgent need of hydraulic fracturing to open the dead-end pores and cracks to ease the mobilization of oil in the reservoir. Although the required water volume in all of the drilled wells in this field had been increased dramatically during the 6 years of production, Fig. 3 revealed that Well-OW-01 had required more volumes of supplied water that is owing to the waste of water in the high permeable layers, and Well-OW-06 have the lowest consumption of water during this period.

Thereby, providing these large volumes of required water for polymer flooding might not be economically profitable, and petroleum industries try to treat flowback water to be reused in the waterflooding performances. The total volume of water which is needed during the years 2010–2015 is statistically explained in Table 3. As it is evident, approximately 32–70% of fresh water had saved entirely in the studied oil field and thereby, about 12 million gallons of fresh water that is saved during the injectivity procedures which provided the water resources for 300 inhabitants per annual.

Required water measurement for hydraulic fracturing operations

Hydraulic fracturing techniques are considered as one of the efficient methods when the recovery processes would not be a good choice for improving the recovery factor, and subsequently, it needs to reopen the blocked cracks or increase the diameter of previous cracks to improve the mobilization of oil in the reservoir. Due to the low efficiency of water flooding in gas wells, the measurement of required water for gas wells is not considered in this investigation, and only the necessary water for hydraulic fracturing processes was investigated for each well, and therefore, it is clarified that what percent of utilized water had returned to the surface. The measurement of this procedure is statistically explained in Table 4. Moreover, according to the measurements of this investigation, it is witnessed that more volume of flowback water is returned to the surface, and subsequently more fresh water saved rather than other operations which are equivalent to the consumption of total water for 1400 inhabitants (about 37,500 gal for each person during the year) per year.

Consequently, as a result of experimental investigation for the studied oil field, the total volume of fresh water which is saved in the water flooding, polymer flooding, hydraulic fracturing, and other application of water utilization are explicitly

Table 3 Total required water and wastewater for polymer flooding after treatment in the period of 2010–2015

Well no.	Total required water (MM gallon)	Total provided wastewater after treatment (MM gallon)	Total fresh water (MM gallon)	Fresh water savings (%)
Well-OW-01	2.47	1.77	0.71	70.55
Well-OW-02	1.86	1.28	0.59	58.82
Well-OW-03	1.80	1.36	0.44	44.27
Well-OW-04	1.74	1.42	0.32	32.32
Well-OW-05	1.68	1.24	0.45	44.66
Well-OW-06	1.62	1.06	0.57	56.53
Total	11.19	8.12	3.07	–

Table 4 Total required water and wastewater for hydraulic fracturing after treatment from 2016 to 2017

Well no.	Total required water (MM gallon)	Total provided wastewater after treatment (MM gallon)	Total fresh water (MM gallon)	Fresh water savings (%)
Well-OW-01	4.46	4.10	0.35	92.10
Well-OW-02	5.98	5.40	0.59	90.18
Well-OW-03	5.54	4.83	0.71	87.15
Well-OW-04	13.65	12.78	0.87	93.61
Well-OW-05	8.35	7.86	0.49	94.13
Well-OW-06	7.62	7.10	0.52	93.16
Well-GW-01	2.72	2.31	0.41	85.10
Well-GW-02	3.86	3.57	0.29	92.51
Well-GW-03	4.91	4.54	0.37	92.51
Total	57.09	52.49	4.60	–

illustrated in Table 5. Moreover, as it is experienced from the results of this comprehensive investigation, the total volume of required water for all processes is measured about 130 million gallons for the period of production commencing from the year 2001 to 2017; in respect of the way, approximately 80% of total required water is provided by the wastewater treatment, and, subsequently, it would save relatively 102 million gallons of fresh water that supply the water resources for the 2750 inhabitants adequately.

The local water or domestic water resources is considered as the primary sources of water supply for human and industrial activities, and lower utilization of fresh water would be operated as a dominant issue against water scarcity. Regarding the enormous demand for hydrocarbon fuels, water consumption in numerous operations has increased dramatically. Thereby, proposing the adequate water treatment procedures which are more adapted to the reservoir characteristics of the drilled formation should be appropriately scheduled to save more expenditures and urgent necessity to local water resources. According to the results of Oetjen et al. (2018), it is clarified that the appropriate treatment procedures of flowback water help to alleviate the adequate drilling and production operations and subsequently have led to more production rate which is virtually eliminated the unnecessary expenses of supplying, transferring, and purifying the demanded water. Hence, this experimental investigation has concentrated on the three reservoir operational performances such as waterflooding, polymer flooding, and hydraulic fracturing which is operated during the life of a well from 2001 to 2017. Oetjen et al. (2018) and Oetjen and Thomas (2016) stated that hydraulic fracturing processes had provided 98% of reused water in the operational circumstances while in the studied field in this evaluation, it is witnessed that about 93% of required water had provided by the treatment of wastewater in the surface in the average value for all the explored wells of this oil field (Oetjen et al. 2017, 2018; Oetjen and Thomas 2016).

Moreover, according to the Horner et al. (2016), it is demonstrated that the property of treated water should be adequately analyzed and those water contents that have a large volume of hazardous materials would be transferred to the disposal well which would be drilled in the nearest locations of the explored wells. Hence, in this oil field, there is a disposal well which is used for the moving of highly contaminated materials which are detected in separation units; disposal wells have operated as an inexpensive way for the inappropriate materials that would have time-consuming and higher expenditures for their treatment (Horner et al. 2016). Iran's oil field has allocated the 10% of total crude oil reserves of conventional oil resources in which about 70% of this volume is located in the onshore oil field while the other is located in the offshore platforms. However, the volume of required water is a challenging issue which is concerned by drilling and exploration industries for several decades, relatively 10% of this water volume should be provided by local freshwater resources because all of the flowback water in the surface is not being adequate (Aghdasinia and Farahani 2010; Bahadori and Zeidani 2012). Thereby, to be obtained the best practical result, the integration of photo-Fenton and flotation technique was applied in this investigation to remove the oil droplets in which the success of this technique is about 99%.

Table 5 Total required water and wastewater for all performances in the period of 2001–2017

Technique	Total required water (MM gallon)	Total provided wastewater after treatment (MM gallon)	Total fresh water (MM gallon)
Waterflooding	55.58	40.18	15.4
Polymer flooding	11.19	8.12	3.07
Hydraulic fracturing	57.09	52.49	4.6
Lubrication performances	1.142	0.642	0.5
Other drilling activities	0.864	0.374	0.49
Total	125.866	101.806	24.06

Conclusion

Regarding the water scarcity phenomenon in the coming decades, the appropriate treatment of wastewater especially for industrial purposes is considered as the principal issues that should be significantly taken into consideration. It is of elaborated that the lower necessity to the local freshwater resources is utterly depended to the validation of treatment processes. In this extensive study, the experimental investigation is based on the waterflooding, polymer flooding, and hydraulic fracturing performances, and the total volume of water supply for each operation is measured accurately. As it is illustrated by the results of each performance, the water treatment procedures would relatively save 80% of required fresh water, and it subsequently affects the water consumption. In addition, the complexity of flowback water is significantly impacted by the reusing opportunities, reclamation and the required possibilities of reinjected water might be adequately estimated; in this study, an oil field unit with the nine exploration wells which six of them are drilled in oil layers and three of them are drilled in gas layers that clearly depicted that gas wells did not need water in the secondary and tertiary enhanced recovery techniques. Other significant conclusions of this comprehensive evaluation are stated as the following concepts:

- Hydraulic fracturing is considered as the most efficient way for the opening of dead-end pores and those cracks that have lower permeabilities to enhance the diameter of cracks and a further increase of permeability. According to the results of this study, the large volume of flowback water is returned to the surface which is explicitly demonstrated that about 93% of injected water would be recycled.
- The total volume of water which is utilized from the beginning day of drilling a well up to 2017 is measured relatively 125 million gallons which are provided only 20% of this volume from local freshwater resources and subsequently help to supply 2750 inhabitants every year.
- A combination method which is based on the flotation and photo-Fenton is developed to remove the oil droplets.

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