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Full Length Article

Influence of bio-clogging induced formation damage on performance of microbial enhanced oil recovery processes

P. Sivasankar[a,b], G. Suresh Kumar[a,*]

[a] Petroleum Engineering Program, Department of Ocean Engineering, Indian Institute of Technology, Madras, Chennai 600036, India
[b] School of Petroleum Technology, Pandit Deendayal Petroleum University, Gandhinagar 382007, Gujarat, India

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ABSTRACT

In-situ microbial enhanced oil recovery (MEOR) is an economical and environment friendlier technique to recover the trapped oil from oil reservoirs. However, its oil recovery efficiency is reduced significantly due to the occurrence of formation damage induced by bio-clogging. Hence, to improve the oil recovery efficiency, it is required to understand the effects of bio-clogging on *in-situ* MEOR processes, which could assist in development of suitable well stimulation strategies. Thus, in the present study, the influence of bio-clogging induced formation damage on *in-situ* MEOR processes has been numerically investigated for different Reynolds number (*Re*) by varying the microbial slug injection rate (Q_n) and for different biosurfactant yield (Y_{PX}) values. It is found out that with lowering of *Re* and increasing the Y_{PX} values, the bio-clogging and sweep efficiency increases, while the swept length decreases. The study determines the critical time and critical distance to perform well stimulation technique, in order to completely evade the detrimental effects of bio-clogging on residual oil recovery. The results revealed that in the absence of bio-clogging: (a) the original oil in place (OOIP) recovered could be increased by 106% and 24.5% by flooding at 1*Re* and 3*Re* respectively from its respective bio-clogging OOIP levels; and (b) the final OOIP recovered at 1*Re* is nearly equivalent to that of 3*Re*. Finally, the study concludes that the oil recovery during *in-situ* MEOR could be enhanced significantly at relatively lower cost by: (a) regularly performing the well stimulation at the prescribed critical time and for critical distance; and (b) selecting microbes with higher Y_{PX} values and flooding them at relatively lower *Re*. Thus, the present study would assist in: selection of suitable Q_n, microbe and nutrients; and efficient planning of well stimulation operations to improve the oil recovery.

1. Introduction

In-situ microbial enhanced oil recovery (MEOR) is a tertiary method to recover the trapped residual oil from oil reservoirs that were left unrecovered after the application of primary and secondary recovery methods [1]. In *in-situ* MEOR technique, either indigenous or non-indigenous microbes are injected into the reservoir, which undergoes metabolic activity by consuming the nutrients, and produces metabolites (biosurfactants, biopolymers, gases, alcohol) within the reservoir, which in turn, recovers the trapped oil within it [1,2]. During the implementation of *in-situ* MEOR technique, the formation damage (reduction in reservoir rock's permeability and porosity) occurs due to microbial clogging/bio-clogging process, in addition to other formation damage processes that includes asphaltene or paraffin deposition, invasion of drilling mud into reservoir rock and fines migration [3]. In comparison with other chemical EOR techniques, *in-situ* MEOR is a cost effective, easy to implement and environment friendlier technique [4,5]. Though *in-situ* MEOR technique inherits several merits, the performance of *in-situ* MEOR process during its field implementation is expected to be retarded mainly by formation damage that occurs due to the clogging of both injected and indigenous microbes near the injection well [2]. This bio-clogging process reduces the rock's hydraulic properties (porosity, permeability) and subsequently restricts the fluid flow within the reservoir [2,6], and hence it could not consider to be insignificant. The growth of microbes that leads to bio-clogging process is prevented by treating the reservoir with biocides (anti-microbial agent), which is one of the well stimulation technique [3]. Thus, understanding the influence of bio-clogging induced formation damage on the performance of *in-situ* MEOR processes would greatly assist in the development of better strategies for well stimulation and for efficient implementation of *in-situ* MEOR technique in the oil fields to achieve the maximum oil recovery.

* Corresponding author.
E-mail addresses: sivasankar@spt.pdpu.ac.in (P. Sivasankar), gskumar@iitm.ac.in (G. Suresh Kumar).

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