EVALUATION OF THE EFFECTS OF KAOLINITE ON THE EFFICIENCY OF OIL RECOVERY BY RADIOACTIVE-ASSISTED LOW SALINITY WATERFLOOD.

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***Abstract*—**

Recently extensive researches are being done on low salinity waterflooding (LSW) as a mean to enhance oil recovery. This study focuses on the impact of kaolinite concentration on the oil recovery by means of radioactive assisted LSW. The LSW experiments conducted are divided into two categories. Firstly, 3 sets (A, B, C) of experiment were conducted using sandpack with varying concentration of kaolin clay (5wt%, 10wt% and 15wt%). The second part of the study include, the use of a radiotracer to help evaluate the sandpack condition during LSW. Kerosene were used as the oil phase of the experiment. Varying results were obtained from each sets of experiments most likely due to the difference in method of preparation of the sandpack prior to LSW. Set A and B showed an increase of recovery with increasing kaolinite concentration. Meanwhile set C and the radiotracers discerned no real correlation between an increase in kaolinite concentration. Highest oil recovery was obtained at 85% of oil originally in place (OOIP) while the lowest was observed at 51% of OOIP. During experimentation, low initial oil saturation was achieved with the kerosene. Water breakthrough occurred much faster in higher concentration kaolinite sandpack. The increase in pH and Multicomponent Io Exchange (MIE) mechanisms are evaluated based on the pH values and final Mg^{2+} and Ca^{2+} concentration of the produced water. The effect of pH increase was only observed in set C experiment. Concentrations of the Mg^{2+} and Ca^{2+} showed an increase as compared to the initial formation water and low salinity brine in all experiments. Radiotracers experiment produced two residence time distribution (RTD) models associated with the sandpacks. Kaolinite containing sandpack were shown to be best fitted with the Perfect mixer in parallel RTD model, while clean sandpack showed more alignment with the perfect mixer in series with exchange.

***Keywords*— corefloading, Enhanced oil recovery, kaolinite Low Salinity Waterflood, Radiotracer, RTD, sandpack,**

I. INTRODUCTION

Oil is primarily recovered by the reservoir natural drive mechanism which are; solution gas, water influx, gas cap drives and/or gravity drainage. However, to further improve production, secondary or tertiary recovery mechanisms tend to be applied. One of the most common method for oil recovery in the world is waterflooding. The attractiveness of waterflood stems from the general availability of water, relative simplicity of the injection, good spreading in the oil reservoir and its high displacement efficiency [1].

LSW is a relatively new method whereby a reduced/desalinated water is injected to the reservoir to enhance the oil recovery (Attar, 2017). The injection of low salinity water into an oil wet reservoir has the potential to disturb the chemical equilibrium between the crude oil, brine and rock (O/W/R). This disturbance in the initial equilibrium of O/W/R will cause the modification of rock wetting phase towards a more intermediate wetting condition, thus, allowing for easier oil recovery [2].

For each reservoir, the conditions for LSW effects to be observed is different. The process of LSW in sandstone rocks have been widely studied well-established. Previous studies indicated there are 5 widely accepted conditions for LSW effects in sandstones [3]:

1. Significant presence of clay or negatively charged surface.
2. Presence of formation water.
3. Presence and exposure to crude oil containing acid or basic polar components to create mixed- or oil-wet initial conditions.
4. Considerable salinity gradient.
5. Presence of multivalent ions in connate water.

This experimental work attempts to assess the effect of the presence and concentration of clay in sandpacks on the improved oil recovery by LSW. Typically, the uneven distribution of clays throughout the sandstone reservoir made it difficult to study the exact impact of the concentration of each clay particle on the wettability alteration and oil recovery.

The clay particles on sand provides the negatively charged surface for the adsorption of the polar components of crude oil which would alter the rock surface to an oil-wet state. Furthermore, the clay minerals would also act as an ion exchanger when it comes into contact with the oil, thereby, resulting in a decrease in cation concentration in the produced water or pH increase [4].

In addition to assessing the oil recovery, the access to radiotracer, Technetium-99m, Tc-99m allowed the analysis of the time for breakthrough and fitting of the best RTD model to each of the constructed sandpack by means of radioactive-assisted low salinity waterflooding. The use and research of radiotracer in the oil and gas industry are sparse. This paper will also attempt to act as a preliminary study on the viability of the use of radiotracer to characterize the sandpack.

II. METHODOLOGY

A. Materials

i. Sand

The sand that was used for the experiment was collected near the Bagan Lalang Sepang Beach (2.595983,101.693319), Selangor, Malaysia and brought back to UiTM, Shah Alam for drying and sieving. The collected sand was oven dried for 2-3 hours at 80°C and sieved up to 150µm using ENDECOTTS OCTAGON 2000 Digital Sieve Shaker

ii. Kaolinite

Kaolin clay powder (R&M Chemicals) was supplied by UiTM. Kaolinite is 1:1 type clay and contains a tetrahedral sheet of silicon (SiO4) and an octahedral sheet of aluminum in one layer and the layers are placed sequentially one above the other.

Kaolinite is not chemically inert and does possess a small net negative charge due to broken bonds at the edges of the kaolinite particles. These small negative charges are stabilized by minor cationic substitutions. The least reactive clay particle in sandstone reservoirs is kaolinite, and it is also classified as a non-swelling type of clay particle. Due to less surface area and less substitutions occurring, they have low CEC and hence low reactivity [5].

iii. Brine

Three samples of brines (Synthetic seawater, formation water and 10x diluted seawater) were concocted for the experiment based on modifications of a previous study [6]. Synthetic seawater and 10x diluted seawater was used to investigate the effect of water salinity on the potential of oil recovery improvement and the mechanisms involved. Properties of the studies brines are presented in Table 1.

Table 1: Injected brine composition

	Formation water	Seawater	10x diluted seawater
NaCl (g/L)	28.295	11.354	1.1354
CaCl (g/L)	0.8867	0.471	0.0471
$MgSO_4$ (g/L)	0.079	1.44	0.144
TDS (ppm)	29260	13265	1326.5

iv. Oil

Kerosene was used as the oil for this experiment. There were however sourced from different areas and stores. The properties of kerosene are displayed in Table 2.

Table 2: Kerosene Properties

Density@20°C	0.805 g/cm^3
Viscosity @25°C	1.64 cP

v. Tracer

The radioactive tracer that was used in this experiment was Technetium-99m, Tc-99m ECD. A Tc-99m generator (DRYTEC 25-100 GBq radionuclide generator) was supplied by the Malaysian Nuclear Agency and NaCl solution was used as the eluate.

B. Methods

i. Kaolinite Sand Preparation

Two methods were used for mixing or coating the kaolin powder with the sand sample.

The first method (method 1), was used to prepare experiment 5-T(A). This method of mixing only required the dry sand to mix with the kaolin powder by placing it in a sealed container and shaken until a uniform color was observed. The second method (method 2) was used in all other kaolin experiment. The first step generally follows the steps mentioned in method 1. However, the mixture of kaolinite and sand were then wet with around 200ml of ultrapure water and then placed in an oven for 2-3 hours at 90ºC to ensure it is completely dried.

The newly dried kaolinite and sand mixture are then sieved up to 300um to 150um for 15 minutes on a ENDECOTTS OCTAGON 2000 Digital Sieve Shaker at 8 amplitudes.

Sand sample from 0-T, 5-T(A), 5-T(B) and pure kaolinite was analyzed using GeminiSEM 500 which was generously provided by the Malaysian Nuclear Agency.

ii. Experimental Setup

The schematics of the system that was constructed is shown in Fig. This schematic shows the layout for the sandpack waterflooding system, which is divided into three sections: the upstream, the sandpack column and the downstream.

The upstream side of the system provides the intermittent injection of brines (formation water, seawater, low salinity water) and kerosene. It consists of a syringe (60ml & 150ml) and a syringe pump (NE-1000, New Era Pump System Inc). The syringe is connected to the pipe fittings of the column through a 7mm ID clear tubes. Continuous injection of fluids could not be achieved as the syringe required additional top ups of brine and oil due to its small capacity.

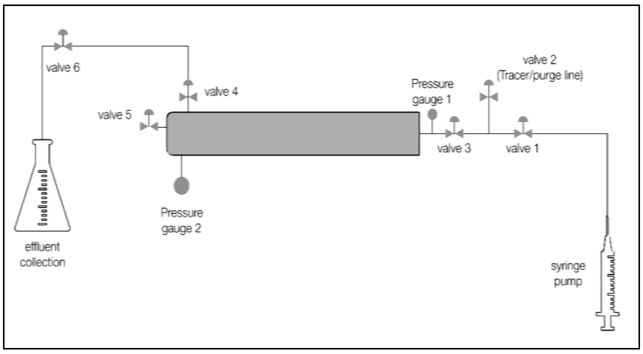


Fig. 1: Core Holder 1 flooding set up

Meanwhile he downstream section consist of a 25ml measuring cylinder for collection of effluents. The use of a small measuring cylinder was for easier reading of liquid value at each interval of injection as it had to be taken manually.

iii. Sandpack Characterization and Establishing Initial Water Saturation

Sand sample was packed inside a column of known volume and saturated with formation water. Initial saturation with formation are conducted in two ways; imbibition through evacuation and injection by syringe pump. Set C experiments were saturated using the second method of saturation as the physical condition observed on the other sets of experiments was highly unsatisfactory. Next, initial water saturation was established by injecting the wet sandpack with kerosene at 1ml/min.

The characterization of each sandpack is summarized in Table 3.

Table 3: Injected brine composition

ID	Dry weight (g)	PV (ml)	Porosity	Swi
0-T	426.5	176.5	46.4%	71%
5-T(A)	496	149	39.2%	51%
5-T(B)	468	158.5	41.7%	45%
5-A	426.5	146	38.42%	60%
10-A	463.04	152	40%	82%
15-A	466.6	132	34.7%	85%
5-B	457.39	142	38.9%	51%
10-B	463.22	152	40%	81%
15-B	460.75	132	34.7%	78%

5-C	480.98	128	33.7%	46%
10-C	488.77	129	33.9%	54%
15-C	485.93	139	36.6%	69%

iv. Aging

Once the initial oil saturation and initial water saturation have been established through displacement with kerosene, all tubing and fittings are drained, and the column is let to sit for one. Due to limitations of time and equipment, the aging process are only done overnight at room temperature.

v. Conventional Low Salinity Flooding Test

Brine is injected intermittently using a syringe pump at a rate of 1 mL/min. Intermittent injection is conducted due to the limitation on the syringe volume (60ml), which had to be changed around every 60 minutes. The injection of brine will displace the oil originally in place in the core holder. The amount of oil produced at effluent is collected and the value is recorded at every interval of 5ml.

The produced fluid was then analyzed using a pH meter and an Atomic absorption spectroscopy (AAS) to determine if there was any increase in pH or drop in Mg^{2+} or Ca^{2+} ion.

vi. Radioactive Assisted Low Salinity Flooding Test

The procedure for the tracer test generally followed the same procedure as the flooding test with the slight modifications. In total 3 tracer tests were conducted with generally similar detector spacing but varying method of tracer injection. The test was conducted using a radioactive tracer, Tc-99m (DRYTEC 25-100 GBq radionuclide generator). The schematics of the tracer tests are illustrated in the figure below:

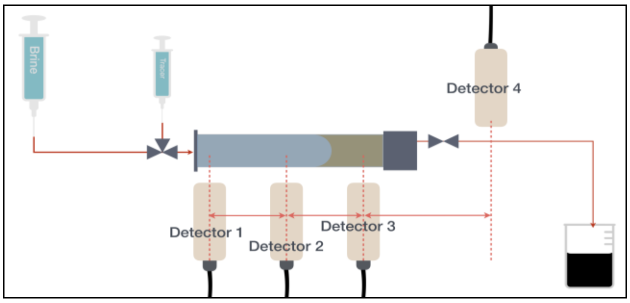


Fig. 2: Tracer flooding test schematic diagram

Three experiments were conducted for the radiotracer experiment which are; the flooding of low salinity water (10x diluted seawater) into: (1) Clean sand (2) 5% clay (dry mixing) and (3) 5% clay (mixed through solution). The spacing measurement between detectors 1-2 are around 9.7cm, detectors 2-3 are 11.5cm and detectors 3-4 are around 3.4cm. The initial tracer activity for each experiment can be seen in Table 4.

Table 4: Parameter of sandpacks and initial tracer activity of the Tc-99m

Experiment ID	Parameter	Tracer Activity (µSv/hr)
0-T	Clean sand	6
5-T(A)	5wt% kaolinite	4
5-T(B)	5wt% kaolinite	1

Two methods of injection were tested during these experiments. For the first experiments, tracer was injected into the column by hand as the syringe pump pushed the water at 2 ml/min. This method was found to be unsuitable as the rates of manual injection and the selected brine were not the same. Thus, for the final two tracer experiments, the tracer was let to sit in the tubing and valve prior to being push into the column alongside the selected brine. However, in experiment 3, water was topped up to the syringe through the tracer injection valve. This caused discrepancies in the results as two waves of tracer was detected for each channel. In experiment 4, the mistake was rectified by using a different syringe once the all volume has been injected from the initial syringe used. Analysis of the produced fluid was the same as in conventional low waterflooding test.

III. RESULTS AND DISCUSSION

A. *FESEM Analysis*

Figure 3 shows the microscopic image of the sand samples. The average particle size for 0-T (Fig. 3A) was found to be in the range of 300-150µm. Visual interpretation of the sample from 0-T was concluded as homogenous. The unsieved sample of 5-T(A) and 5-T(B) showed a more variation in its grain size as can be observed in Fig. 3B and Fig. 3C respectively

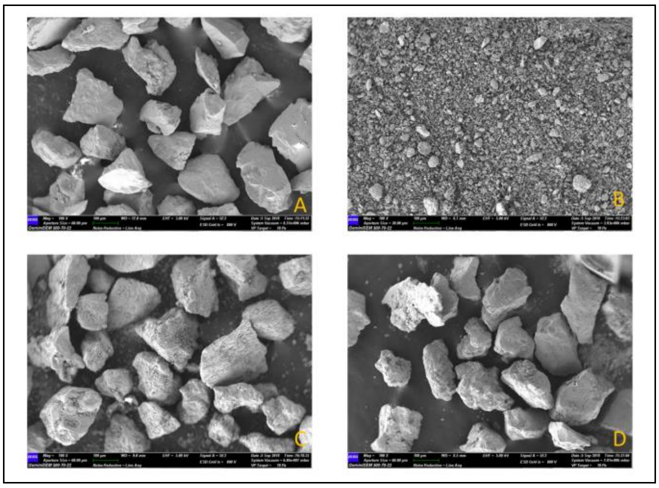


Fig. 3: microscopic image of (A) pure sand sample from 0-T, (B) pure kaolin powder, (C) 5-T(A) sand, D 5—T(B) sand.

For experiment 5-T(A), from Fig. 3(C) it can be observed that the coating was superficial as the kaolin particle can be seen to simply sit atop the sand particle. The coating in 5-T(B) sample in Fig. 3D was seen to be subtler as less uncoated kaolin particle as the surface seems to be more even.

Elemental analysis of the sample is tabulated in Table 5. While the component spectrum map is displayed in Fig. 4. The coating of kaolinite on sand was evaluated based on the increase of the weight percentage of aluminum of the sample. The results showed that the coating was generally successful by both method of physical mixing or by wetting and drying method. Analysis of both 5-T(A) and 5-T(B) samples showed a general increase to 5wt% of aluminum. However, in some areas of sand from sample 5-T(A), aluminum concentration reading was as high as 15wt%. In comparison, the clean sand sample produced a result indicating a base value of 1.05wt% of aluminum.

Table 5: Results of the Elemental Analysis using FESEM

	0-T	5-T(A)	5-T(B)
Element	Wt%		
O	56.23	57.98	59.25
Na	0.53	0.86	0.75
Mg	0.42	0.42	0.27
Al	1.05	5.69	4.88
Si	40.44	33.62	33.61
Cl	0.8	1.06	0.71
Fe	0.32	0.36	0.38

Cu	0.2	-	0.17
Total:	100.00	100.00	100.00

B. Analysis of the Effect of Kaolinite Concentration on Oil Recovery.

The % of OOIP recovered are representative of the displacement efficiency of the LSW process. For the first two sets of experiment, it can be observed in Fig. 5 that a higher kaolin content resulted in a higher overall recovery. These results coincided with Seccombe and Jerauld whereby their studies also showed an increasing recovery trend with an increase of the kaolinite concentration in the core during LSW [7], [8].

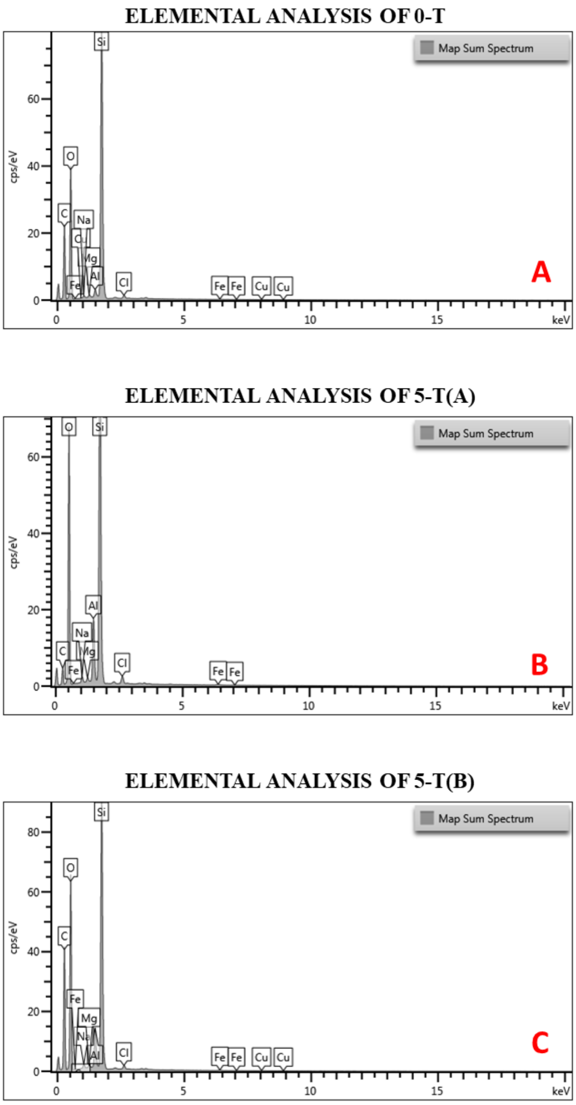


Fig. 4: Component Spectrum Map for (A) 0-T(A) (B) 5-T(A) (C) 5-T(B) sandpack sample

However, contradictory results were observed from the set C experiments. Experiment 5-C,10-C and 15-C showed no real correlation between the kaolinite concentration and the amount of oil recovered. This is aligned with results from several previous studies which concluded that clay concentration does not act as the primary mechanism for the increase in oil recovery by LSW but instead, improvement of oil recovery was believed to be more influenced by the distribution of clay [4], [9]–[11].

Oil recovered at each interval of 5ml was recorded for all experiment. Fig. 6 compiles all the data obtained to allow better visualization. From the figure, it can be concluded that water breakthrough generally occurs faster in sandpacks with higher kaolinite concentration. This again, may be attributed to its higher tendency of fracturing as kaolinite may have blocked open pores thus continuous injection into the sandpack would cause pressure to increase to a point greater than fracture pressure of the sandpack. The increasing pressure would then induce fractures in the sandpack causing channeling of the injected water.

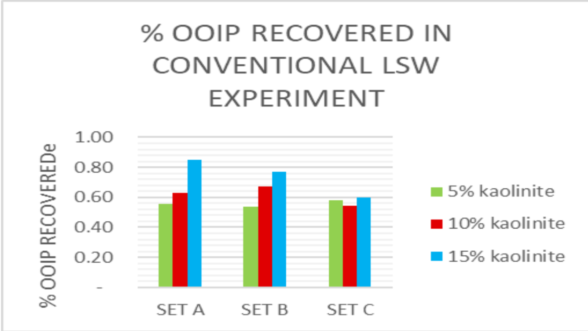


Fig. 5: % of OOIP Recovered by Conventional LSW Experiments

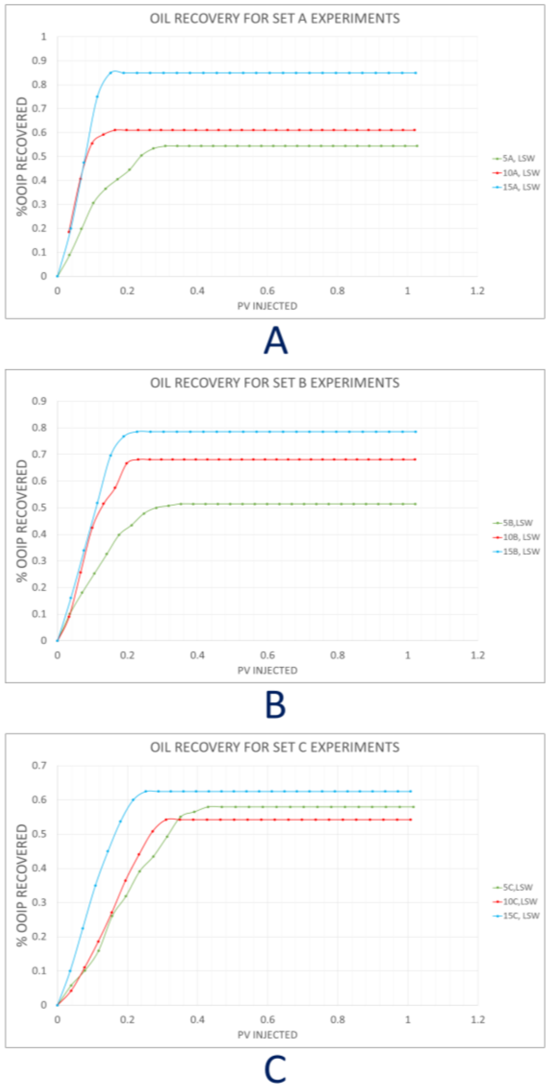


Fig. 6: Oil Recovery vs PV Injected in (A) set A (B) set B and (C) set C experiments

C. Analysis of pH increase mechanism

Analysis of the pH of produced water was done to compare the possible activity of pH increase mechanisms for improved oil recovery by LSW. The initial pH for the formation water and low salinity water was recorded at 7.16 and 7.89 respectively. As can be seen in Fig. 7, the produced water from the set A and set B experiments showed no significant increase or difference from the initial pH of the formation brine and low salinity brine.

Only set C showed an increase in pH of the produced water. This may be explained by the longer contact time and area between the brine and sand body. This is said as no fractures were observed in the sandpack for the set C experiment. Thus, it is assumed that the low salinity brine was well dispersed within the sandpack during injection as compared to set A and B which exhibits high degree of fracturing. The fractures minimized the contact between the sand body and low salinity brine. This caused the inability of the brine to properly disperse and contact with most of the clay sections of the sandpack.

Table 6: Results of the Conventional LSW

ID	Porosity (%)	pH of produced water	% OOIP recovered
5-A	38.42	7.16	56
10-A	40	7.09	61.11
15-A	34.7	7.73	85
5-B	38.9	7.81	57.25
10-B	40.7	6.92	68.18
15-B	34.7	7.06	78.57
5-C	33.7	10.81	57.97
10-C	33.9	9.29	54.24
15-C	36.6	8.74	60.00

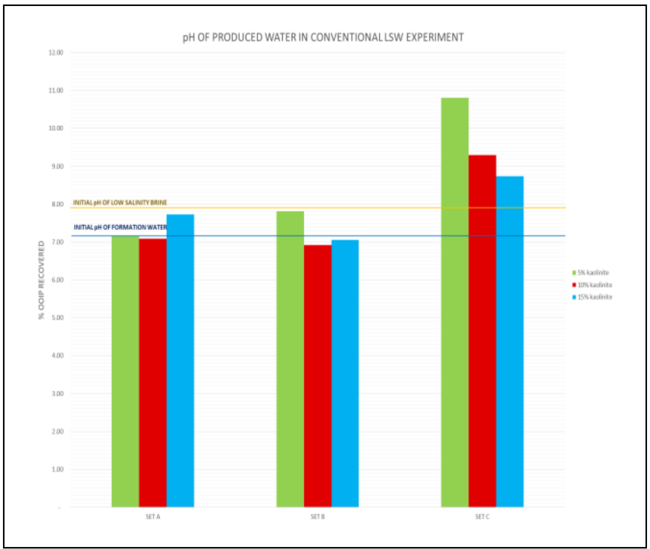


Fig. 7: Comparison of the pH of the produced water in each experiment

D. *Analysis of MIE mechanism*

Contrary to results obtained by Lager et al. [12] the analysis of produced water showed an increase in presence of Mg^{2+} and Ca^{2+} as compared to the initial concentration present in formation water. This suggested that the previously cited MIE mechamisms for the increase in oil recovery by LSW was not active. It should be noted that this result may have risen because of the lower initial Mg^{2+} ions in formation water than in the low salinity water. Lager explained MIE as the cation exchange of the mineral surfaces and the injected brine. It was suggested that this cation exchange would occur by a strong presence of Mg^{2+} and Ca^{2+} gradient between the initial formation water and the injected brine. This however, was not the case for the formulated low salinity brine composition used in this study. I

Thus, as can be seen in Fig. 8 all produced water experienced an increase in salinity from the initial 19.865ppm of Mg^{2+} and ppm Ca^{2+} of formation water and 34.135ppm of Mg^{2+} and 51.69ppm Ca^{2+} of low salinity brine. This suggested that cation exchange may have occurred in the reversed direction, whereby the initially absorbed cations are desorbed off the clay sands during flooding with low salinity brine.

It was believed that the modified brine composition from Zhang [6] was not suited for the activation MIE mechanism in LSW. This is because of the lower Mg^{2+} concentration in formation water than in low salinity brine. In comparison, other studies were shown to utilize a formation brine of a much higher Mg^{2+} and $Ca^{2=}$ concentration as compared to the low salinity brine [9], [12], [13].

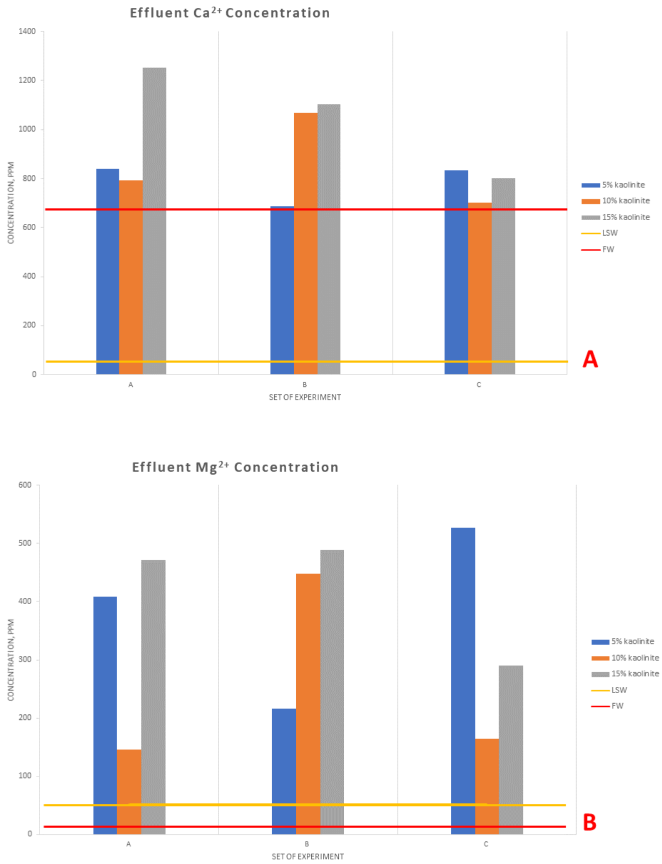


Fig. 8: Comparison of the Ca^{2+} & Mg^{2+} of the produced water in each experiment. (A) Ca^{2+}, (B) Mg^{2+}.

E. *Analysis of the RTD System for the Radioactive-Assisted Low Salinity Waterflooding Experiments*

Three radiotracer experiments were managed to be conducted in the span of three weeks. However, only three experiments were related to this study. Initially, the tracer had an expiry date of 12th August 2018, however on the day of the last experiment on the 20th, it was found that the tracer still managed to produce a detectable 1 µSv/hr. Thus, the experiment was followed through.

The water flooding results for the tracer experiment is tabulated in Table 7. Results obtained in the tracer assisted LSW showed a higher recovery in clean sand as compared to the clay containing sand. One possible explanation of this is due to the eluate used. Injection of the Tc-99m into the low salinity brine was done through the use of NaCl solution. This may have caused an increase in the salinity of the brine which could have hampered the low salinity effect of LSW for oil recovery.

Table 7: Results of the Radioactive-Assisted LSW

Experiment ID	0-T	5-T(A)	5-T(B)
Porosity (%)	46.45	39.21	41.84
So_i	24.46	49.19	55.03
pHi	7.03	6.9	7.04
pH	6.87	7.14	7.19
% recovery	61.54	55.93	51.43
Tracer activity (μSv/hr)	6	2	1
Time to breakthrough (hrs)	≈ 0.0833	0.877	1.129
PV to breakthrough	≈ 0.0567	0.706	0.845
Best fitted RTD model	Perfect mixer in series with exchange	Perfect mixer in parallel	Perfect mixer in parallel
RMS	4.00E-10	8.28E-11	3.03E-10

Table 8 shows the comparison of the RMS obtained for each RTD model in each of the experiment. The assignment of the RTD model to each sandpack was based on the lowest RMS values obtained when the RTD software was ran.

As previously suggested, the initial condition of the sandpack after initial formation water and oil saturation have a huge impact in the results of sandpack coreflooding. Analysis of the raw data suggested that experiment 5-T(B) required the longest time for tracer breakthrough which indicated lower levels of channeling. The tracer breakthrough results of 5-T(A) and 5-T(B) however are somewhat incomparable to 0-T due to the difference in method of tracer injection. 0-T results an almost instant breakthrough of tracer due to rapid manual injection of tracer into the coreflooding system.

The results showed that the sandpacks generally followed the 'perfect mixers with exchange' or the 'perfect mixers in parallel' model as displayed in Fig. 9. The difference between results may have been due to the different methods of injections applied and the initial condition of the sandpack. In theory however, explanations on both models seem to fit the sandpack reservoir. As previously mentioned in chapter 2, cation exchange may occur in the presence of clay minerals and quartz. One of the main mechanisms of improved recovery by low salinity waterflooding is due the multicomponent ion exchange, whereby the wetting state of rocks changes in response to the release of oil component that had been previously bonded to the negatively charged clay surface by the divalent cations present in the brine. It was suggested that low salinity water acted by allowing easier desorption of oil bearing divalent ions due to the exchange of H^+ present in the liquid phase with the cations that was absorbed during the aging process [3].

Analysis of Mg^{2+} concentration in Fig. 10(B) of the produced water in all three tracer experiments again showed an increase when compared to the initial the concentration present in the formation water and low salinity brine. The biggest difference was observed in experiment 0-T which would explain its lean toward the perfect mixers with exchange RTD model. It should again however be noted that the manual injection by hand of the radiotracer during 0-T experiment could have cause an inaccuracy in the associated RTD model.

As previously discussed, the presence of kaolinite in the sandpack of 5-T(A) and 5-T(B) caused an increase in the tendency of fracturing, thus the characterization of the kaolinite laden sandpacks were not as suited to the perfect mixer in series with exchange RTD model. It should however be noted that both kaolinite containing sandpack experienced a slight increase in pH as observed in Table 7 which may indicate the exchange of H^+ present in the liquid phase with the cations that was absorbed during the aging process.

Meanwhile, the 'perfect mixers in parallel' RTD model which is more aligned with the experiments conducted on the kaolinite laden sandpack (5-T(A) & 5-T(B)) may possibly be explained by occurrence of fractures and collapse of the sandpack as previously explained. Through the various experiments conducted, it was found that the presence of kaolinite caused embrittlement of the sandpack. Since initial water saturation was conducted by inducing water into a vacuumed sandpack, the high velocity of water was not able to be controlled. Such strong flow of water created channels and caused collapse in some portion of the sandpack. Furthermore, the presence of kaolin had possibly reduced the permeability of the sandpack; although this was not able to be verified due to faulty pressure gauges, coupled with the relatively high injection flow rate during initial oil saturation, may have increased the pressure of the sandpack above its fracture pressure. As the sandpacks generally have a low fracture pressure, the high pressure may have induced channeling throughout the sandpack. This created sections of high (fractures) and low (tightly packed) permeable layers within the column of sand in which the tagged water flowed through. These variation of flow paths throughout the sandpack may explain the affiliation of the 5-T(A) and 5-T(B) sandpack with the 'perfect mixers in parallel' RTD model.

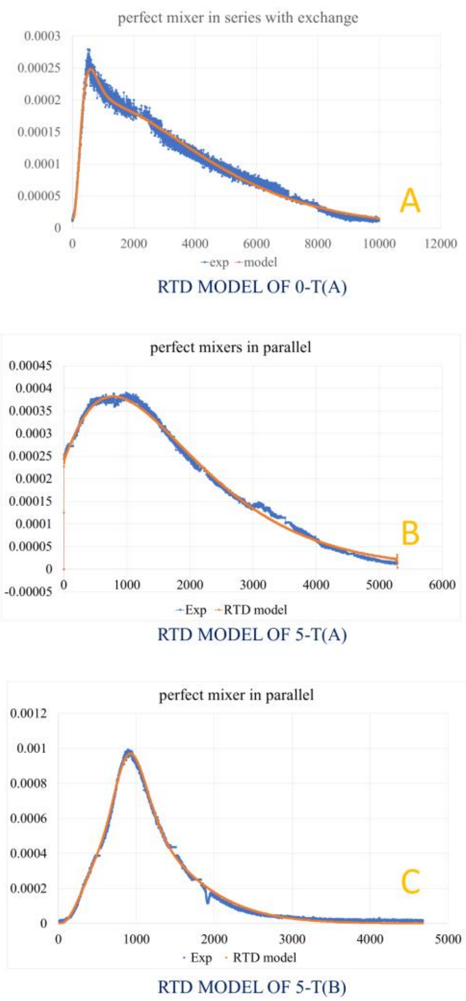
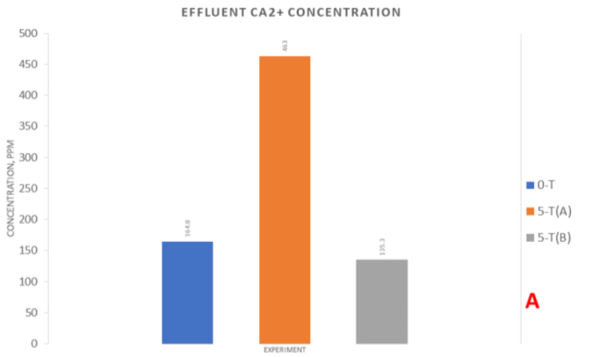


Fig. 9: Best fitted RTD model for each of the Radioactive-Assisted LSW experiments (A) 0-T, (B) 5-T(A), (C) 5-T(B).



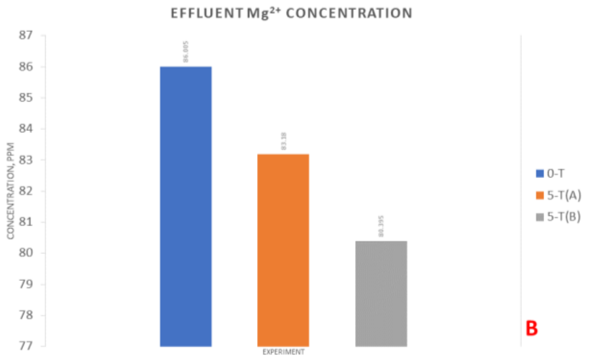


Fig. 10: AAS analysis of produced water for tracer experiments. (A) Ca^{2+}, (B) Mg^{2+}.

Table 8: Comparisons of the RMS values of each RTD model in each of the radioactive-assisted LSW experiments

Experiment ID	1	3	5
	RMS		
Perfect mixture in series	-	3.50E-10	2.11E-09
Perfect mixer in series with exchange	4.00E-10	1.12E-10	1.11E-09
Perfect mixers in Parallel	-	8.28E-11	3.03E-10

IV. CONCLUSION

In a properly packed sand column with no evident occurrence of fractures, the concentration of kaolinite in the sandpack sample does not seem to play a role in the improved oil recovery. However, the presence of clay is required for the low salinity effects to take place. The activation of LSW mechanisms discussed in literatures varies with the condition of the sandpack. It would seem that the physical condition of the sandpack plays an important role in the activation of the LSW.

The improved oil recovery by low salinity was seen to be characterized by an increase in pH and decrease in Mg^{2+} and Ca^{2+} concentrations.

The presence of fractures caused channelings of the low salinity brine which reduce the activation of the low salinity mechanism. This was evident by the stagnant or decrease in pH from the initial formation water and low salinity brine.

The use of a sandpack as a mean to evaluate effect of kaolinite may not be suitable for future research as the sandpack has a generally low fracture pressure thus blockage of the pore due to the presence of clay produced high pressure that would induce fracture which may impact the reliability of the results obtained.

Assessment of the sandpack by using radiotracer, Tc-99m was a success. The use of a radiotracer to characterize the sandpack and flow condition during coreflooding experiment was found to be viable. However, it is believed that the NaCl eluate may have tampered with the low salinity effect of the low salinity brine. The RTD curve evaluation yielded 2 models associated with the sand sample. The clean sand (0-T) aligned with the perfect mixer in series with exchange model which suggested that a possible MIE mechanism was activated during the waterflood, although this conclusion should be taken with criticism as the method of tracer injection was questionable.

Meanwhile, kaolinite laden sandpack showed the tendency towards the perfect mixers in parallel RTD model, most likely due to the occurrence of fractures and channelings in the sandpack.

Further research must be conducted on the feasibility of the radiotracer in the industry. Although the use of Tc-99m is relatively safe when properly handled, broader considerations such as thermal degradation must be accounted during selection of tracers. In future corefloods experiment, the half-life of the tracer may also be one of the critical parameter to account for as typical coreflood experiments may run for more than 8 hours for a rate of 0.1ml/min. This, gradual drop in activity during the flooding thus may cause discrepancies in the result.

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