Optimization of Oil Recovery Using Heated Low Salinity Water (HLSW) in the Horizontal Sand Pack Column during Water Flooding: Radiotracer Intervention

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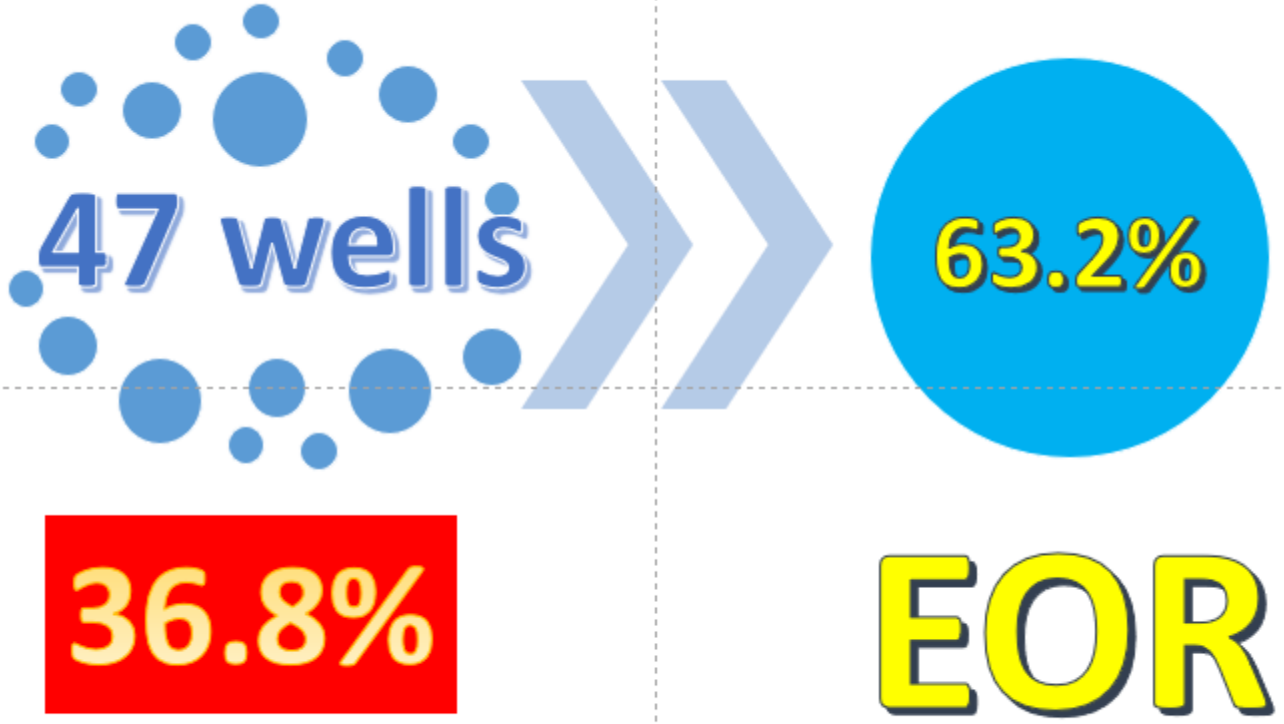
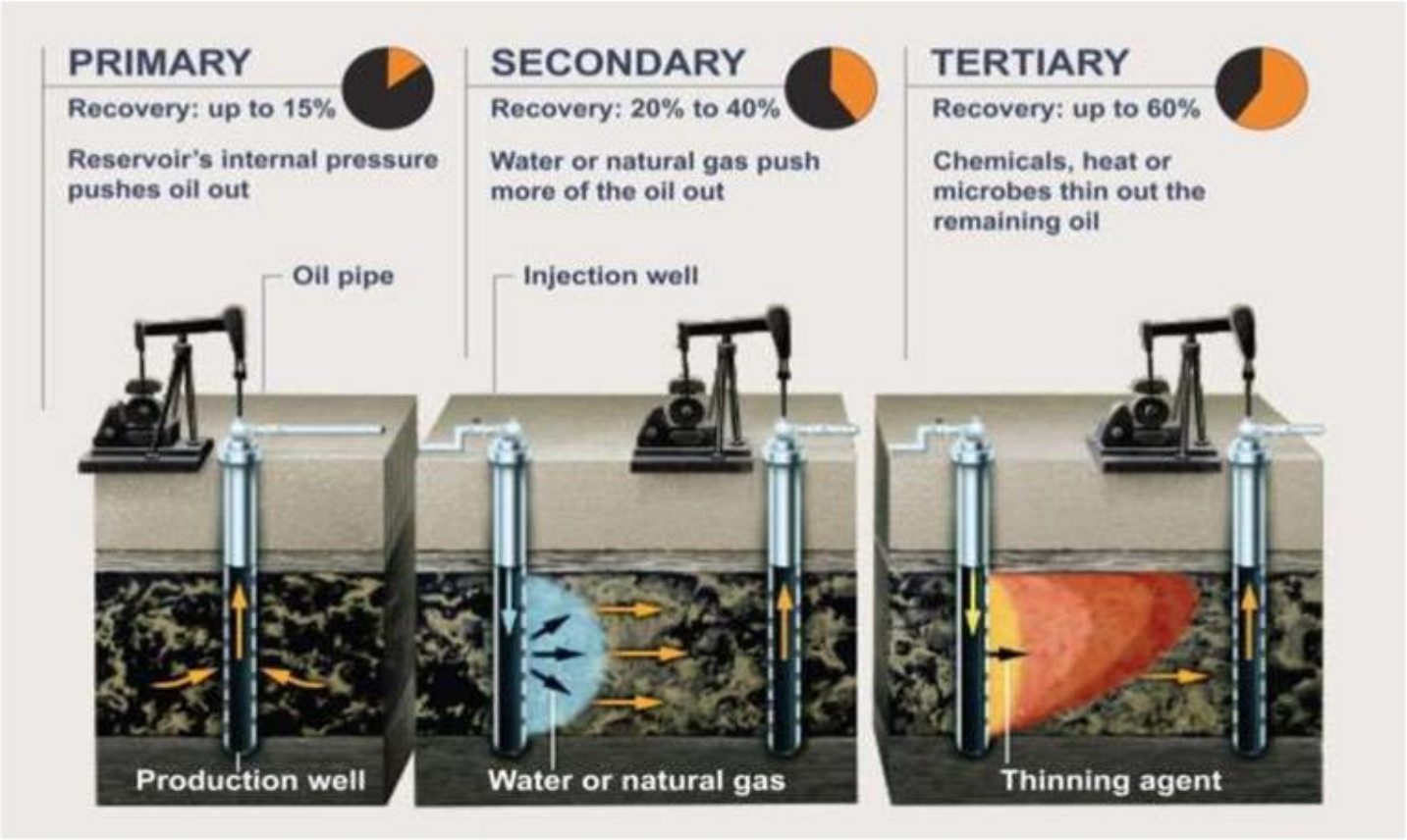
INTRODUCTION

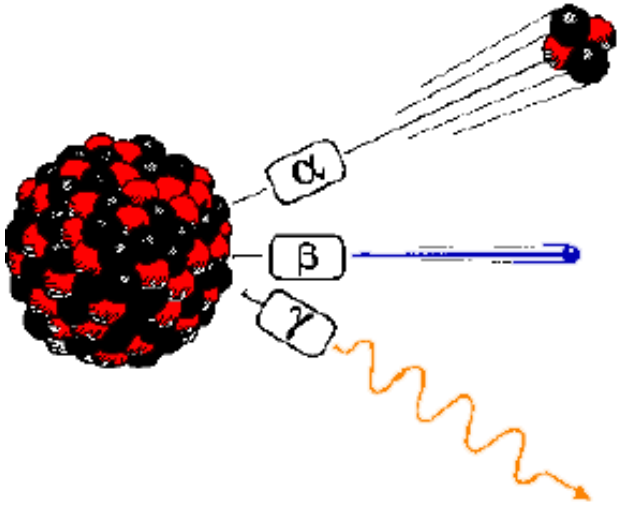


WHAT IS ENHANCED OIL RECOVERY (EOR)?



Source: https://petgeo.weebly.com/thereservoir.html

WHAT IS RADIOTRACER?



OBJECTIVES

- To optimize the process parameters of water-flooding activity for enhancing oil recovery
- To diagnose any process anomalies using Residence Time Distribution measurement

METHODOLOGY: Optimization Experiment

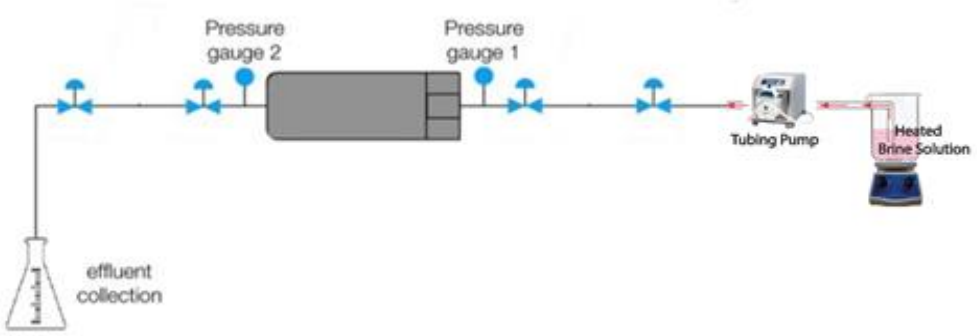
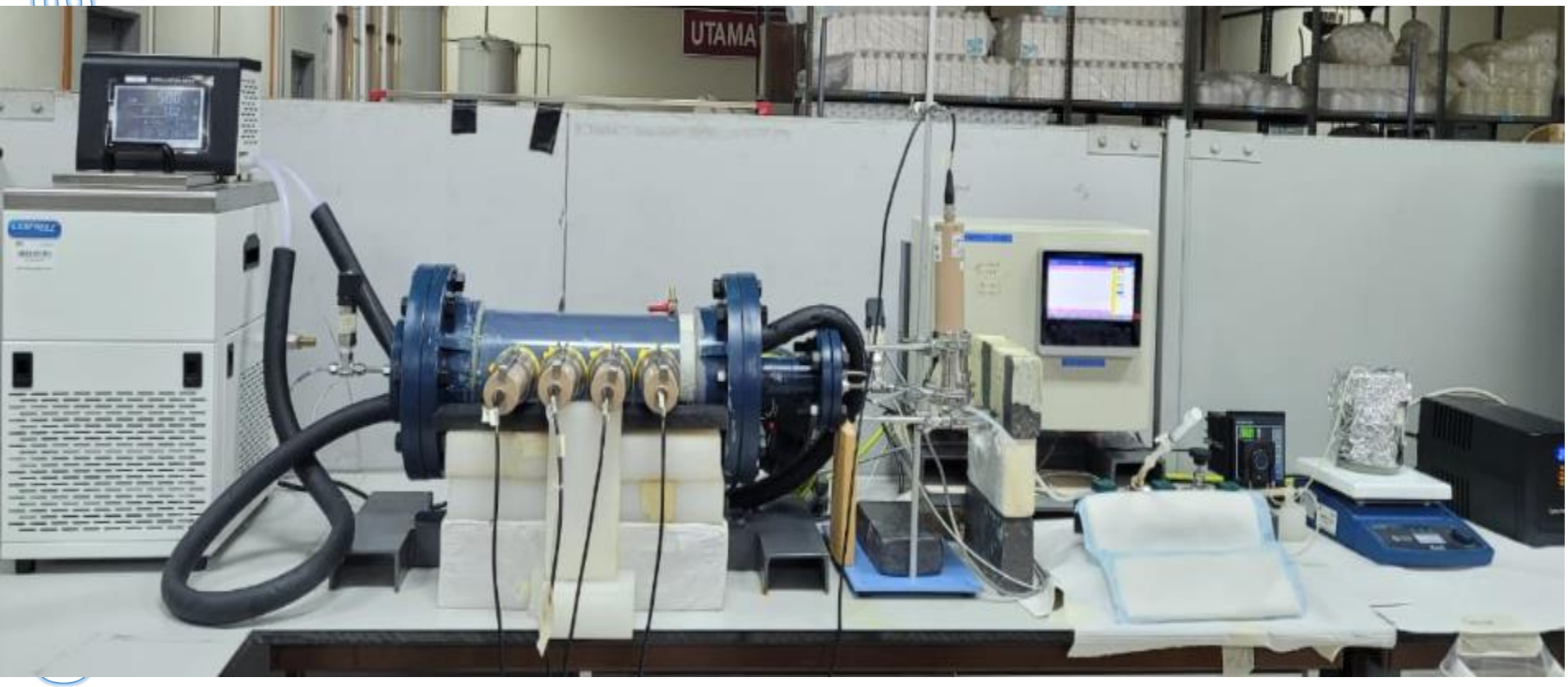


Table 1. Composition of formation water and low salinity water

Chemicals	Formation Water	Brine Solution (100ppm)
NaCl(g)	28.295	0.1
CaCl(g)	0.887	-
$MgSO_4$	0.079	-
Distilled Water (L)	1	1
Tapis Oil (viscosity)	0.001382 Pa.s (1.382cP)	
Temperature (°C)	-	50,70,90
Flow rate (ml/min)	-	1,2,3

METHODOLOGY: Radiotracer Experiment



RESULTS

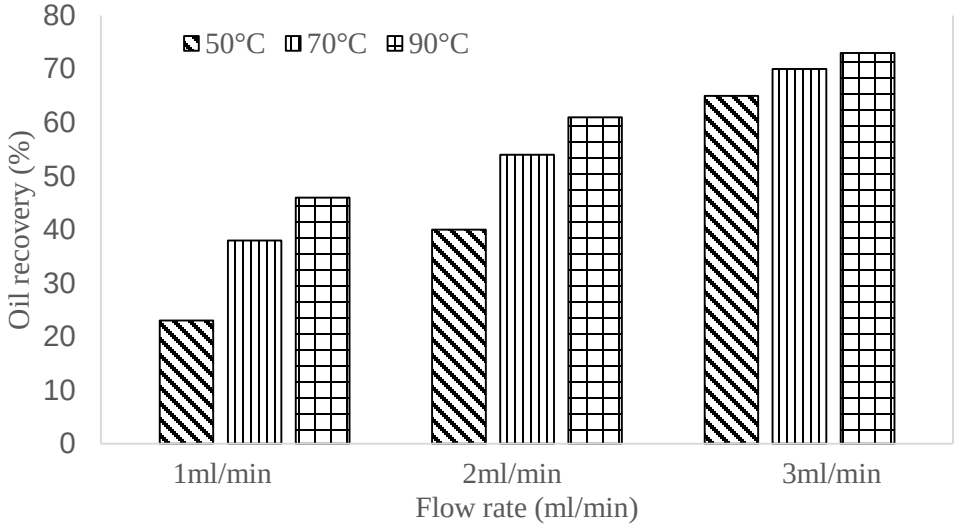
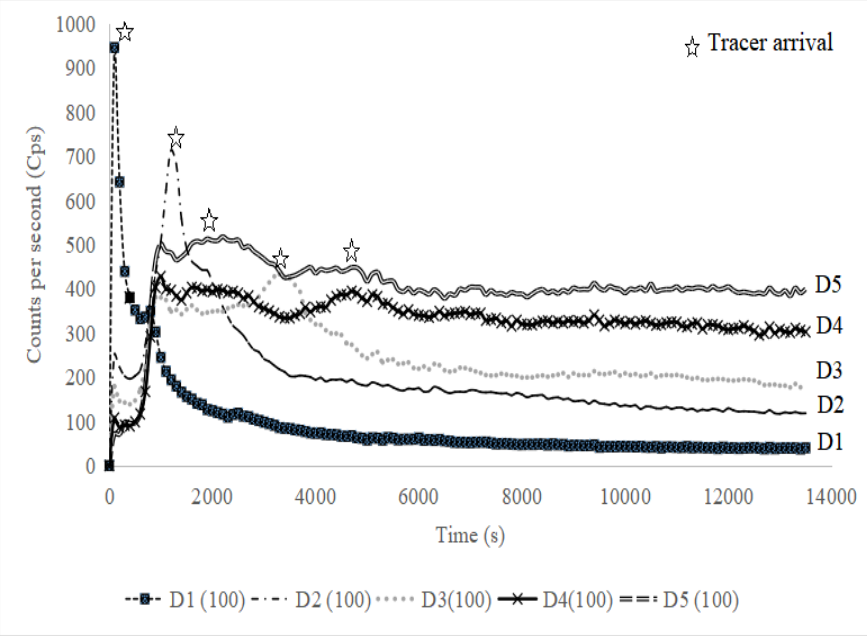
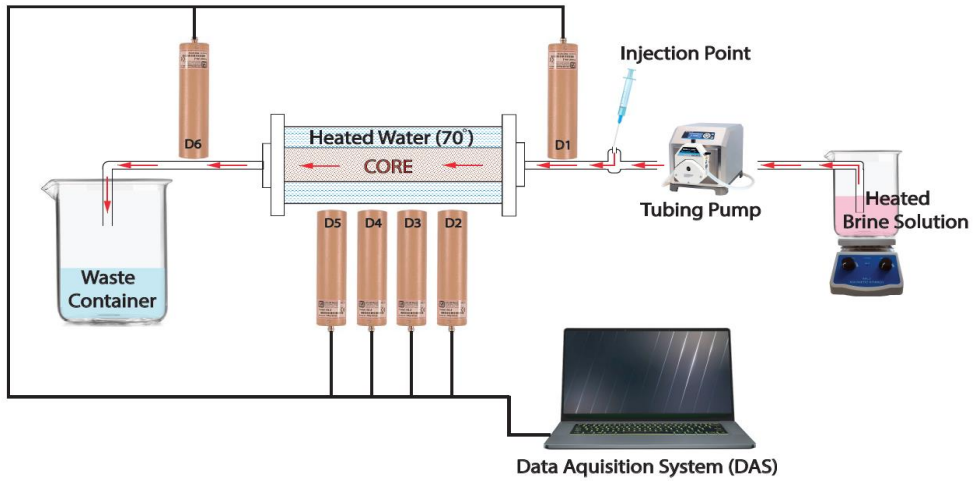


Table 2. Oil Recovery from Various Salinity Concentration

Authors	Remarks	Arrangement of column	Original Oil In Place (OOIP) (%)
Present study	Heated Low Salinity Water (HLSW)(100ppm)	Horizontal	73.0
Noraishah Othman et al. (2022)	300 ppm	Vertical	62.1
N.Othman et al. (2021)	500 ppm	Vertical	66.7
Danial Azim Che Aziz et al. (2020)	15 wt% kaolinite concentration	Horizontal	55%
Noraishah Othman (2020)	30,000 ppm brine solution	Horizontal	38.37%

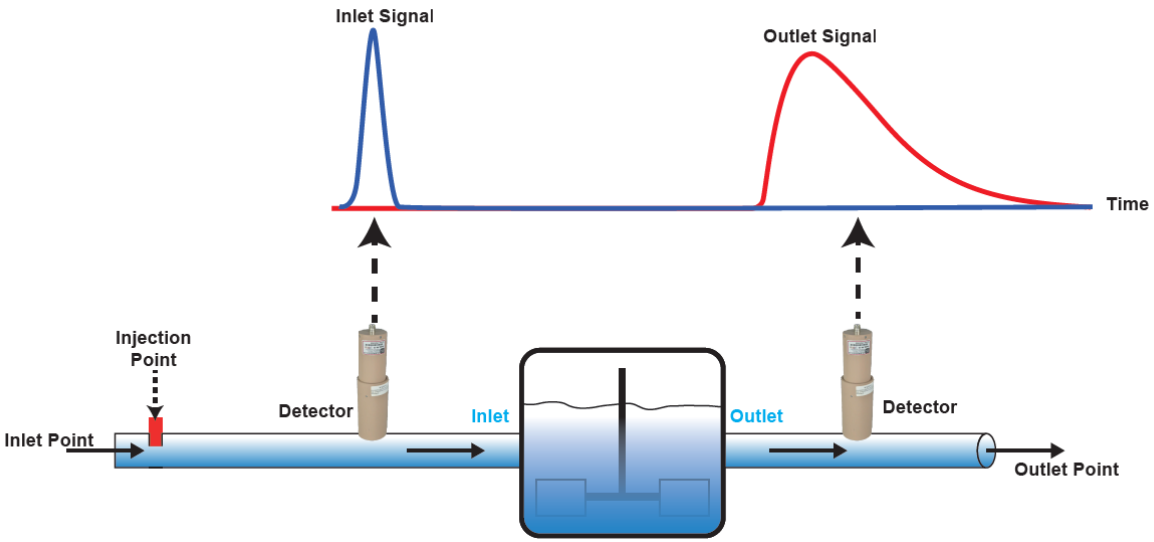
RADIOTRACER EXPERIMENTS





Legend
CORE = Residual Oil + Formation Water + Sand
D1-D6 = Detector

RESIDENCE TIME DISTRIBUTION (RTD) ANALYSIS



Experimental RTD

$$E(t)=\frac{C(t)}{\int_0^\infty C(t)dt}$$

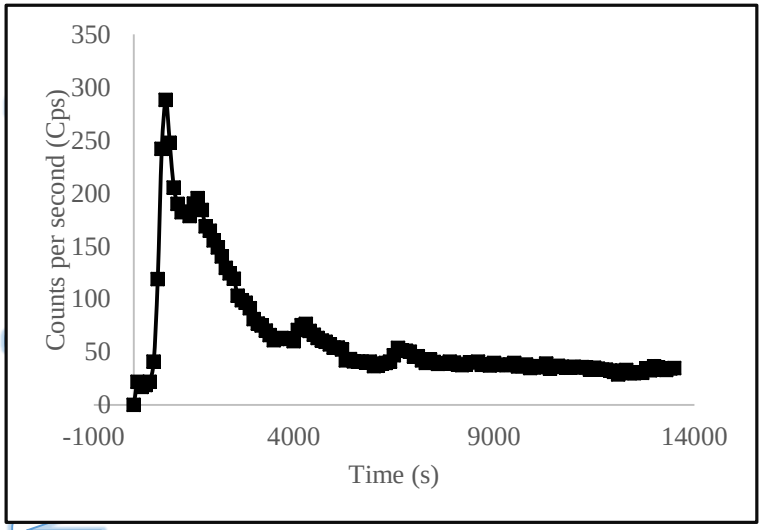
Theoretical MRT

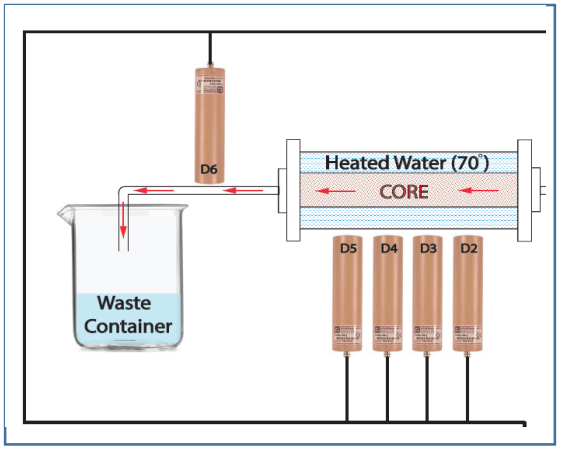
$$\bar{t}=\frac{V}{Q}$$

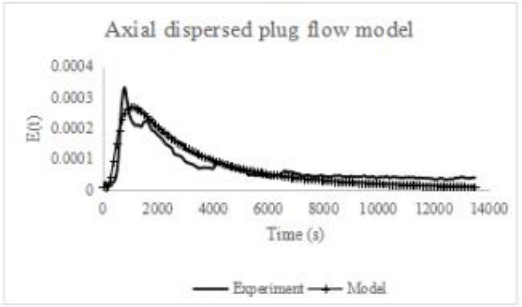
Exp MRT

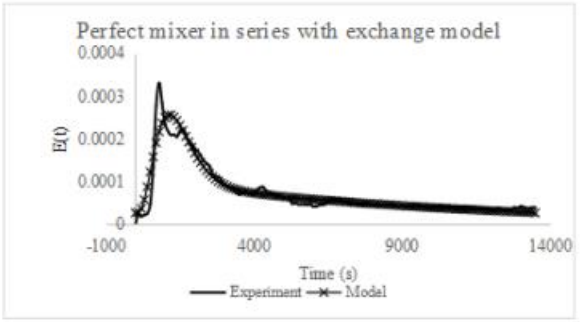
$$\tau=\int_0^\infty tE(t)dt$$

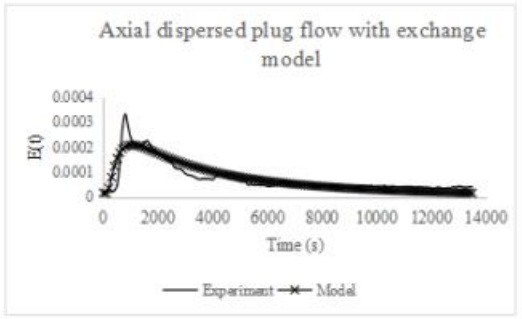
RTD MODELS

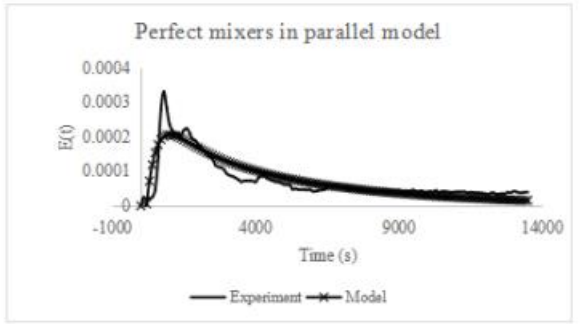


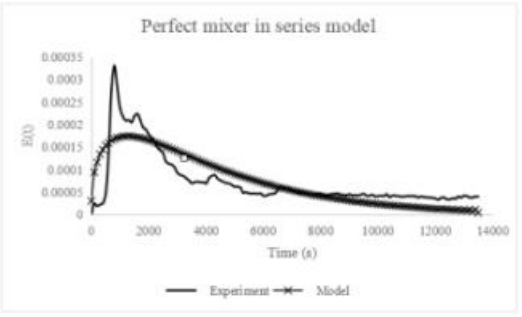


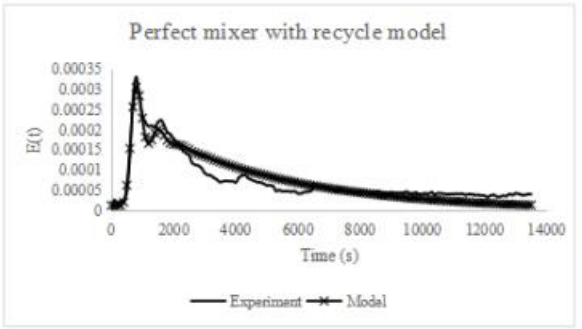










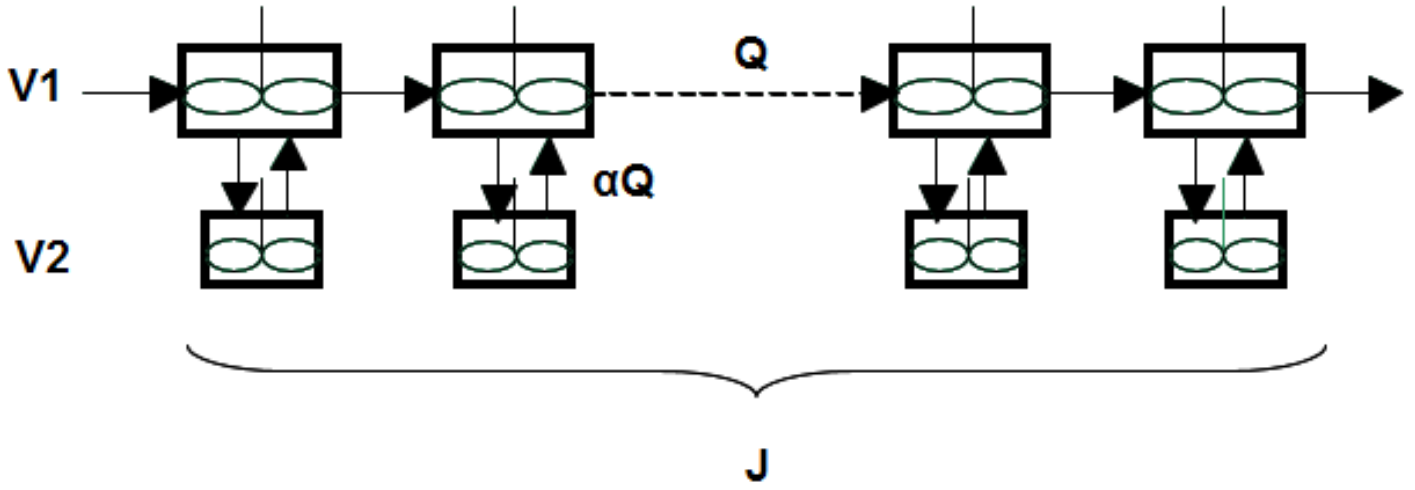


RTD Models with respect to IAEA recommendation

Table 3. Sum of Squares Sum of Squares Error

Models	Parameters									SSE
	Pe	N	τ_1	τ_2	J_1	J_2	T_m	K	Q_1/Q_2	
Axial dispersed plug flow	1.5		4636							0.762×10^{-9}
Axial dispersed plug flow with exchange	1.1	1.0	2910		1.0					0.753×10^{-9}
Perfect mixers in series			4325		1.4					1.46×10^{-9}
Perfect mixers in series with exchange			1824		4.4		4800	3.3		0.364×10^{-9}
Perfect mixers in parallel			4434	313	0.73	1.0			1.2	0.805×10^{-9}
Perfect mixers with recycle			8571	-173	185	-0.32×10^{7}			5.9	0.463×10^{-9}

*τ=mean residence time, J= Number of tanks, Pe=Peclet number, k=V_1/V_2, T_m=residence time for exchange zone



Flow mechanism of perfect mixers with exchange model (IAEA 2008)

CONCLUSIONS

- Heated Low Salinity Water (100ppm, 3ml/min and 70^{o}C) increases the oil recovery
- The perfect mixers with exchange model –RTD Model
- Presence of two zones: active and stagnant zone
- MRT for stagnant zone is longer than active zone
- Necessary action should be conducted by reservoir engineer to modify the wettability and reduce the IFT or increase the sweep efficiency of oil


THANK YOU!