

# THE INFLUENCE OF WET AND DRY SEASONS CONDITIONS ON CHEMICAL COMPOSITIONS, PROPERTIES AND TOTAL SUSPENDED SOLIDS OF DIFFERENT WATER SOURCE AND TYPE IN RIAU-OIL FIELDS

By: Tjuwati Makmur<sup>1)</sup> and Nuraini<sup>2)</sup>

<sup>1)</sup> Researcher, <sup>2)</sup> Earth Investigator at "LEMIGAS" R & D Centre for Oil and Gas Technology  
Jl. Ciledug Raya, Kav. 109, Cipulir, Kebayoran Lama, P.O. Box 1089/JKT, Jakarta Selatan 12230 INDONESIA  
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## ABTRACT

*Change of wet and dry seasons conditions have major impact, the results of chemical compositions concentration determination for RRV, RST, ORK, KWT, KWL and PRD water samples (sampling in dry seasons) are higher than in wet seasons.*

*All of the analyzed water samples don't results in the occurrence of calcium sulfate. Only PRD water has potential to form calcium carbonate scale, because pH value in a range of 7.85 – 8.10 (pH >7).*

*The RRV, RST, ORK, KWT, KWL and PRD (sampling in wet and dry seasons) have poor injection water quality, because the concentrations of total suspended solids (TSS) in the analyzed water samples are higher than 8 ppm.*

*Key words: cations, anions, chemicals compositions, properties, sampling in wet and dry seasons, injection water samples.*

## I. INTRODUCTION

One of oil industries in Indonesia is concerned about potential formation damage issues caused by the quality of the RRV water used for killing wells. The RRV water injection is performed to kill wells when maintenance team needs to work on the pumping unit while doing preventive or corrective maintenance. Whilst there will undoubtedly exist a large volume of data on the historic water injection performance, it will be particularly difficult to definitively determine if the water quality is causing formation damage from this data.

Formation damage may result from a variety of conditions. A systematic approach is therefore necessary in the design and execution of engineering laboratory core flow tests in order to generate realistic data which might be scaled to appropriate field conditions to optimize solutions for formation damage.

The injection water that is used for killing wells,

should fulfill requirements as good injection water and will not cause formation damage. Six alternative sources of injection water may be able used for killing wells. Chemical compositions, other properties and total suspended solids in the six injection water were analyzed as initial tests to determine the quality of its injection water. This paper is focused on the results of injection water quality tests with using API-RP45 in order to know good or not quality of the injection water before used for killing wells.

## II. WATER SOURCE AND TYPES

Oilfield engineers utilize water from a variety of source, such as rivers, lakes and the produced water . In a general way, water from different sources can be characterized according to its salinity or total dissolved solids. Fresh water is generally obtained from rivers or lakes with low total dissolved solids concentration, less than 2000 ppm, while TDS in the produced water is in a range of 5000 ppm – 150,000

ppm. This research used six alternatively water source samples, namely: RRV, RST, ORK, KWT, KWL and PRD.

### III. SCOPE OF WORKS AND STANDARD OPERATIONAL PROCEDURE

Rainfall, evaporation, geological nature of watershed, and seasonal change in the stream flow generally affect the quality of river water. Relation to these, water sampling were carried out twice in wet (see Figure 4.1) and dry seasons (see Figure 4.2). Water sources sampling were carried out twice; in wet and dry seasons conditions in order to know whether there were difference of the results of water quality under different seasons conditions. The water quality tests on the six alternatively water source samples (RRV, RST, ORK, KWT, KWL and PRD) were carried out with using API – RP45 standard operational procedure, which were specifically focused on:

- a. Chemical compositions of cations.  
Sodium ( $\text{Na}^+$ ), calcium ( $\text{Ca}^{+2}$ ), barium ( $\text{Ba}^{+2}$ ), magnesium ( $\text{Mg}^{+2}$ ), iron ( $\text{Fe}^{+3}$ ) ions.
- b. Chemical compositions of anion.  
Chloride ( $\text{Cl}^-$ ), carbonate ( $\text{CO}_3^{=}$ ), bicarbonate ( $\text{HCO}_3^-$ ), sulfate ( $\text{SO}_4^{=}$ ), hydroxide ( $\text{OH}^-$ ).
- c. Other properties.  
Specific gravity (sg), pH, salinity, hydrogen sulfide ( $\text{H}_2\text{S}$ ), hardness, resistivity.
- d. Total dissolved solids.
- e. Total suspended solids.

### IV. RESULTS AND DISCUSSIONS

Results of RRV, RST, ORK, KWT, KWL injection water analysis (water sampling in wet season condition) are presented in Table 4.1, followings are some main points which are derived from these tests:

1. Calcium ( $\text{Ca}^{+2}$ ) and bicarbonate ( $\text{HCO}_3^-$ ) are dominant positive ions (cation) and negative ion (anion) for the analyzed water.
2. Concentrations of calcium ion ( $\text{Ca}^{+2}$ ) of all injection water samples are low in a range of 8.10 ppm – 12.10 ppm.
3. Concentrations of bicarbonate ion ( $\text{HCO}_3^-$ ) of all injection water samples are low in a range of 9.20 ppm – 33.60 ppm.

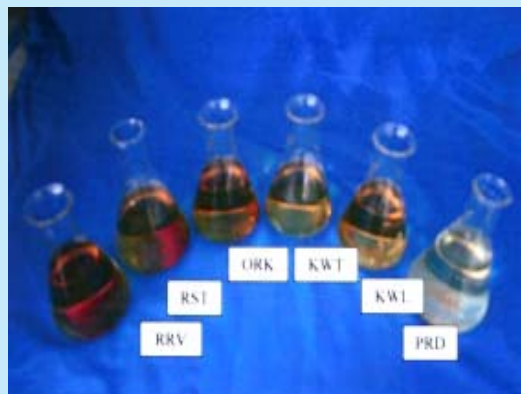


Figure 4.1  
Water sample in wet season condition

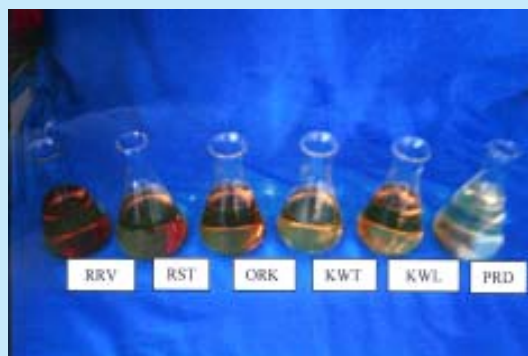


Figure 4.2  
Water sample in dry season condition

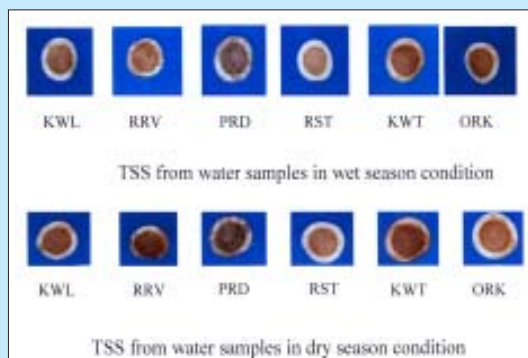


Figure 4.3  
Comparison of TSS from water samples  
in wet and dry season condition

**Tabel 4.1**  
**The results of injection water analysis in wet season condition**

| Laboratory Tests                           |               | RRV    | RST    | ORK    | KWT    | KWL    | PRD      |
|--|---------------|--------|--------|--------|--------|--------|----------|
| <b>Dissolved Solids</b>                    |               |        |        |        |        |        |          |
| <b>Cation (mg/l)</b>                       | <b>Unit</b>   |        |        |        |        |        |          |
| Sodium, Na <sup>+</sup> (calc)             | mg/L          | 1,10   | 2,30   | 1,10   | 5,97   | 8,97   | 736,80   |
| Calcium, Ca <sup>++</sup>                  | mg/L          | 12,10  | 12,10  | 12,10  | 12,10  | 8,10   | 24,20    |
| Magnesium, Mg <sup>++</sup>                | mg/L          | 2,00   | 3,00   | 4,90   | 2,50   | 2,00   | 7,40     |
| Iron, Fe <sup>++</sup> (total)             | mg/L          | 3,40   | 3,40   | 3,40   | 9,00   | 10,10  | 0,00     |
| Barium, Ba <sup>++</sup>                   | mg/L          | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,10     |
| <b>Anion (mg/L)</b>                        |               |        |        |        |        |        |          |
| Chloride, Cl <sup>-</sup>                  | mg/L          | 17,90  | 17,90  | 17,90  | 17,90  | 17,90  | 642,70   |
| Bicarbonate, HCO <sub>3</sub> <sup>-</sup> | mg/L          | 9,20   | 12,20  | 33,60  | 22,00  | 27,51  | 959,90   |
| Sulfate, SO <sub>4</sub> <sup>=</sup>      | mg/L          | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| Carbonate, CO <sub>3</sub> <sup>=</sup>    | mg/L          | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| Hydroxide                                  | mg/L          | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| <b>Other Properties</b>                    |               |        |        |        |        |        |          |
| Specific Gravity, 60/60 °F                 |               | 1,0078 | 1,0078 | 1,0064 | 1,0078 | 1,0107 | 1,0093   |
| pH @ 77 °F                                 |               | 5,85   | 6,00   | 6,90   | 6,65   | 6,60   | 8,10     |
| Hydrogen Sulphide                          | mg/l          | Nil    | Nil    | Nil    | Nil    | Nil    | Nil      |
| Salinity                                   | mg/l          | 33,00  | 34,90  | 49,30  | 41,30  | 45,80  | 1.676,50 |
| Hardness                                   | mg/l          | 38,45  | 42,55  | 50,34  | 40,50  | 28,45  | 90,84    |
| TDS (Total Dissolved Solids)               | mg/L          | 50,00  | 50,00  | 80,00  | 60,00  | 65,00  | 2.400,00 |
| Resistivity at 125 °F                      | (ohm - meter) | > 10   | > 10   | > 10   | > 10   | > 10   | 2,00     |

4. Concentrations of sulfate (SO<sub>4</sub><sup>=</sup>), hydroxide (OH<sup>-</sup>) and carbonate (CO<sub>3</sub><sup>=</sup>) of all injection water samples are zero ppm.
5. Salinity concentrations of all injection water samples are in a range of 33 ppm – 49.30 ppm.
6. All injection water samples show hardness with concentration in a range of 28.45 ppm to 50.34 ppm.
7. Concentrations of total dissolved solids (TDS) of all injection water samples are in a range of 50 ppm – 80 ppm.
8. pH values of all injection water samples show in a range of 5.85 to 6.90.
9. Subsequently, resistivity values are > 10.

While, PRD water sample (sampling in wet season condition) indicates the results as follows:

- a. Concentrations of calcium ion is 24.20 ppm.
- b. Concentration of bicarbonate ion is 959.90 ppm.
- c. Concentrations of sulfate (SO<sub>4</sub><sup>=</sup>) and carbonate

(CO<sub>3</sub><sup>=</sup>) ions of all injection water samples are zero ppm.

- d. Salinity concentration is 1,676.50 ppm.
- e. Hardness concentration is 90.84 ppm.
- f. pH value is 8.10
- g. Concentration of total dissolved solids (TDS) is 2,400 ppm.
- h. Concentration of total suspended solids (TSS) is 48.80 ppm.
- i. Resistivity value is 2.0

Next, results of RRV, RST, ORK, KWT, KWL injection water analysis (water sampling in dry season condition) are shown in Table 4.2. Some main points are summarized from these tests:

1. Calcium (Ca<sup>+2</sup>) and bicarbonate (HCO<sub>3</sub><sup>-</sup>) are dominant positive ions (cation) and negative ion (anion) for the analyzed water.
2. Concentrations of calcium ion (Ca<sup>+2</sup>) of all injection water samples are low (12.10 ppm).

**Tabel 4.2**  
The results of injection water analysis in dry season condition

| Laboratory Tests                           |             | RRV    | RST    | ORK    | KWT    | KWL    | PRD      |
|--|-------------|--------|--------|--------|--------|--------|----------|
| <b>Dissolved Solids</b>                    |             |        |        |        |        |        |          |
| <b>Cation (mg/l)</b>                       | <b>Unit</b> |        |        |        |        |        |          |
| Sodium, Na <sup>+</sup> (calc)             | mg/L        | 42,80  | 41,20  | 41,90  | 106,20 | 100,00 | 654,70   |
| Calcium, Ca <sup>++</sup>                  | mg/L        | 12,10  | 12,10  | 12,10  | 12,10  | 12,10  | 36,40    |
| Magnesium, Mg <sup>++</sup>                | mg/L        | 4,90   | 7,25   | 4,90   | 2,50   | 7,15   | 4,90     |
| Iron, Fe <sup>++</sup> (total)             | mg/L        | 2,30   | 0,60   | 2,20   | 1,70   | 1,10   | 0,00     |
| Barium, Ba <sup>++</sup>                   | mg/L        | 6,00   | 8,00   | 8,00   | 7,00   | 5,00   | 21,00    |
| <b>Anion (mg/L)</b>                        |             |        |        |        |        |        |          |
| Chloride, Cl <sup>-</sup>                  | mg/L        | 89,30  | 89,26  | 89,30  | 178,50 | 178,50 | 624,80   |
| Bicarbonate, HCO <sub>3</sub> <sup>-</sup> | mg/L        | 12,20  | 36,70  | 18,30  | 30,60  | 36,70  | 807,10   |
| Sulfate, SO <sub>4</sub> <sup>=</sup>      | mg/L        | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| Carbonate, CO <sub>3</sub> <sup>=</sup>    | mg/L        | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| Hydroxide                                  | mg/L        | 0,00   | 0,00   | 0,00   | 0,00   | 0,00   | 0,00     |
| <b>Other Properties</b>                    |             |        |        |        |        |        |          |
| Specific Gravity, 60/60 °F                 |             | 1,0029 | 1,0019 | 0,9994 | 1,0007 | 1,0015 | 1,0042   |
| pH @ 77 °F                                 |             | 6,30   | 6,20   | 6,55   | 6,75   | 7,00   | 7,85     |
| Salinity                                   | mg/l        | 162,00 | 166,60 | 160,40 | 309,60 | 314,80 | 1.545,30 |
| Hydrogen Sulphide                          | mg/l        | Nil    | Nil    | Nil    | Nil    | Nil    | Nil      |
| Hardness                                   | mg/L        | 50,34  | 59,97  | 50,34  | 40,50  | 59,57  | 111,09   |
| TDS (Total Dissolved Solids)               | mg/L        | 180,00 | 210,00 | 220,00 | 390,00 | 410,00 | 2.180,00 |
| Resistivity at 125 °F                      | Ohm - meter | > 10   | > 10   | > 10   | 9,68   | 9,51   | 1,99     |

**Tabel 4.3**  
Comparison of the results of TSS concentration determination in dry and wet season conditions

| No. | Laboratory test | Season condition | RRV   | RST   | ORK   | KWT   | KWL   | PRD   |
|-----|-----------------|------------------|-------|-------|-------|-------|-------|-------|
| 1   | TSS (ppm)       | Wet              | 18,50 | 16,67 | 12,00 | 11,25 | 14,00 | 48,80 |
| 2   | TSS (ppm)       | Dry              | 34,09 | 32,62 | 30,08 | 28,12 | 23,12 | 56,25 |

- Concentrations of bicarbonate ion (HCO<sub>3</sub><sup>-</sup>) of all injection water samples are low in a range of 12.20 ppm – 36.70 ppm.
- Concentrations of sulfate (SO<sub>4</sub><sup>=</sup>), hydroxide (OH<sup>-</sup>) and carbonate (CO<sub>3</sub><sup>=</sup>) of all injection water samples are zero ppm.
- Salinity concentrations of all injection water samples are in a range of 160.40 ppm - 314.80 ppm.
- All injection water samples show hardness with concentration in a range of 40.50 ppm to 59.97 ppm.
- Concentrations of total dissolved solids (TDS) of all injection water samples are in a range of 180 ppm – 410 ppm.
- All injection water samples show high concentration of total suspended solids (TSS) in a range of 23.12 ppm to 34.09 ppm.

10. pH values of all injection water samples show in a range of 6.20 to 7.00.
11. Resistivity values are in a range of 9.51 to higher than 10.

While, PRD water sample (see Table 4.2) presents:

- a. Concentrations of calcium ion is 36.40 ppm.
- b. Concentration of bicarbonate ion is 807.10 ppm.
- c. Concentrations of sulfate ( $\text{SO}_4^{=}$ ) and carbonate ( $\text{CO}_3^{=}$ ) ions of all injection water samples are zero ppm.
- d. Salinity concentration is 1,545.30 ppm.
- e. Hardness concentration is 111.09 ppm.
- f. pH value is 7.85
- g. Concentration of total dissolved solids (TDS) is 2,180 ppm.
- h. Concentration of total suspended solids (TSS) is 56.25 ppm.
- i. Resistivity value is 1.99

The concentration of TSS in the RRV, RST, ORK, KWT, KWL injection water samples (see Figure 4.3) are high, these case may be caused by solids particles from silt, clay and the environment of river or lake.

Comparison of the results of total suspended solids in the analyzed water samples after sampling in wet and dry seasons conditions can be seen in Table 4.3. The concentration of total suspended solids (TSS) in RRV, RST, ORK, KWT, KWL water samples mentioned (sampling in wet season condition) are very high in a range of 11.25 ppm to 18.50 ppm. Then, concentration of total suspended solids in RRV, RST, ORK, KWT, KWL water samples (sampling in dry season condition) are in a range of 23.12 ppm to 34.09 ppm and higher than concentration of TSS for water sampling in wet season condition. For PRD water sample (see Table 4.3 and Figure 4.3), the concentration of TSS in dry season condition is 56.25 ppm and higher than wet season condition (48.80 ppm). According to Applied Water Technology, when TSS concentration is higher than 8 ppm, indicates poor water quality. The total suspended solids contain bacteria growth, scale, corrosion products, oil content, silt, clay and insoluble chemicals. The RRV, RST, ORK, KWT, KWL and PRD (sampling in wet and dry seasons) show poor water quality (TSS > 8 ppm).

## V. CONCLUSIONS

Based on water sampling to the field directly, literature and the results of laboratory tests can be concluded as follows:

1. The results of chemical compositions analysis from dry water samples are higher than wet water samples.
2. The RRV, RST, ORK, KWT, KWL and PRD water don't indicate calcium sulfate scale, because these have low calcium and zero sulfate concentrations. So, the TSS in the water samples are solids particles from silt, clay and the environment of river or lake.
3. The RRV, RST, ORK, KWT, KWL and PRD water don't have potential to form calcium carbonate scale, because firstly, pH values don't exceed 7. Secondly, low calcium and carbonate concentrations.
4. PRD water samples taken from dry and wet seasons have potential to form calcium carbonate scale, because:
  - a. Both PRD water samples from two different seasons have pH values in a range of 7.85 – 8.10.
  - b. When the water samples have pH values more than 7 and contain dominant calcium ion (24.20 ppm – 36.40 ppm) and dominant bicarbonate ion (807.10 ppm -959.90 ppm) will result in the occurrence of calcium carbonate scale.
5. The RRV, RST, ORK, KWT, KWL and PRD (sampling in wet and dry seasons) show poor water quality (TSS > 8 ppm).

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