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Characterization of Porang and Xanthan Gum Solutions for Polymer Flooding

Andrian Sutiadi¹, Jacob Siahaya¹, Fajri Maulida¹, Dwi Atty Mardiana¹, Muhammad Taufiq Fathaddin^{1*}, Rini Setiati¹, Pri Agung Rakhmanto¹, Sonny Irawan²

¹Department of Petroleum Engineering Department, Faculty of Earth Technology and Energy, Universitas Trisakti, Jl. Kayai Tapa 1, Jakarta Barat, Indonesia, 11440

²Department of Petroleum Engineering, School of Mining and Geosciences, Nazarbayev University, Qabanbay Batyr Ave 53, Nur Sultan, Kazakhstan, 010000

*Corresponding Author: muh.taufiq@trisakti.ac.id

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Abstract

Porang tubers contain glucomannan which is used in various industries. Porang is a biopolymer that has the potential to be applied in polymer flooding in oil reservoirs. In this research, a combination of porang and Xanthan gum was used for displacing oil in the laboratory. The samples analyzed varied with polymer concentrations of 2000, 4000, and 6000 ppm respectively for porang solution, Xanthan gum, and a mixture of porang and Xanthan gum. The salinity of the formation water used in this research was 6000, 12000 and 18000 ppm. The experiment aimed to observe the characteristics and performance of porang and Xanthan gum including testing for compatibility, viscosity, adsorption and sandpack flooding. Based on the test results, all samples were compatible. The application of a mixture of porang and Xanthan gum provided lower adsorption compared to the application of only Xanthan gum. The highest reduction in adsorption value given was 3.545 mg/gr. The highest viscosity and additional recovery factor were given by a mixture of porang and Xanthan gum with a concentration of 6,000 ppm and a salinity of 18,000 ppm, namely 284.72 cP and 16.1%, respectively.

INTRODUCTION

The EOR method can change the properties of rock and reservoir fluids such as viscosity, mobility ratio of oil and water, interfacial tension and wettability. There are several types of EOR methods which are differentiated based on the type of material used in the injection, namely thermal injection (steam flood and hot water), miscible gas injection (CO₂, N₂, hydrocarbon gas, natural gas mixture), chemical injection (polymers, surfactants, alkalis), and microbial EOR (Green and Willhite, 2018).

The enhanced oil recovery (EOR) method which uses chemical injection is a technique to increase petroleum production by adding chemicals to the injected water. This is done to increase sweep efficiency and reduce oil saturation in the reservoir so that oil recovery can increase. There are three types of chemicals that are generally used in chemical injections, namely polymers, surfactants and alkalis (Ansyori, 2018). One type of chemical EOR that is widely used is polymer injection (Putra & Kiono, 2021; Fathaddin, et al., 2024).

Polymer injection plays a role in increasing the mobility ratio so that it does not cause fingering and increases sweep efficiency (Zhang et al., 2018; Abirov & Eremin, 2019). Polymers that can be applied in the EOR method must have certain characteristics, including being soluble in water, having high viscosity at low concentrations, having thermal resistance, having mechanical stability, and also good salinity (Arina & Kasmungin, 2016). Increasing the viscosity of the injection fluid to the oil, causes the sweep efficiency of the polymer injection to increase. So, oil recovery can be increased (Agi et al., 2018; Chen et al., 2020; Chen et al., 2021).

In the oil and gas industry, three types of polymers have been developed. The types of polymers are synthetic polymers such as hydrolized polyacrylamides (HPAM), secondly organic polymers or often called biopolymers in the form of polysaccharides such as xanthan gum, and the third type of polymer is hydrophobically associated polymers (Saleh et al., 2017). Apart from xanthan gum, biopolymers also have the potential to be used in polymer injection to increase sweep efficiency, including Schizophyllan (derived from the mycelium of *Schizophyllum commune* mushroom), potato peels, chitosan polymer, seaweed, green grass jelly leaves (*Cyclea barbata* Miers), and black grass jelly (*Mesonopalustris*). Chitosan can be made from shrimp shells and crab shells (Gao, 2015; Ayoola et al., 2018; Fathaddin et al., 2024). Green grass jelly, seaweed, cotton leaves and shrimp shells contain hydrocolloids which are polymer components derived from plants, animals, microbes or synthetic components which generally contain hydroxyl (Herawati, 2018).

Biopolymers have drawn interest recently as possible agents for enhanced oil recovery (EOR) because of their ability to improve oil extraction procedures while also being environmentally friendly. Optimizing natural polymers like xanthan gum, guar gum, and polysaccharides as well as bio-based synthetic substitutes has been the main goal of the development of biopolymers for EOR in order to increase the viscosity and mobility of the injected fluids in oil reservoirs. These biopolymers aid in fluid displacement, water flooding technique efficiency, and the reduction of oil-water interfacial tension. Additionally, scientists have been working to improve the heat stability, salt resistance, and biodegradability of biopolymers in order to guarantee their performance in challenging reservoir conditions. Furthermore, the application of biopolymers in EOR has been investigated to lessen the environmental effects of conventional chemical agents, with a growing focus on affordable, sustainable options.

One of the biopolymers that has the potential for enhanced oil recovery is porang (*Amorphophallus oncophyllus*). Porang is a plant that has great potential as a source of glucomannan. Glucomannan is used as a thickener, gel former, texture improver, water binder, stabilizer and emulsifier (Yanuriati et al., 2017). This research was based on previous research which used biopolymers containing hydrocolloids to improve the quality of the polymer which was used as a reference and background for this research. In this study, a mixture of porang and xanthan gum was used to compare the quality of the two polymers. The focus of this research is to determine the characteristics of adding porang to the xanthan gum solution. Xanthan gum and porang are two substances that have hydrophilic properties that have the ability to bind water (Wu et al., 2017; Yaseen et al., 2004). The bond between these two materials does not involve a strong covalent bond, but rather a physical interaction and complementarity in gel formation. The amount of gel formed depends on the water absorption capacity of the two materials. The properties of gels are influenced by the size and valency of the cations in the solutions in addition to the gellan concentration. Notably, the development of crystalline areas in gellan was significantly influenced by water (Hatakeyama & Hatakeyama, 1998; Zhang et al., 2016; Chandrasekaran et al., 1988; Tako et al., 1989).

MATERIAL AND METHOD

The tools used were magnetic stirrer, digital scales, dropper pipettes, bottles, chemical glasses, stopwatch, Ostwald viscometer, UV visible spectrophotometer, and sandpack flooding. While, the materials used were distilled water, 40 and 60 mesh sand grains, natrium chloride (NaCl), Xanthan gum, and porang.

The preparation of tool and material was the first step in the research process. Subsequently, solutions were prepared with salinities of 6000 ppm, 12000 ppm, and 18000 ppm. Polymer solutions containing 2000 ppm, 4000 ppm, and 6000 ppm of polymer were then produced. The polymer composition for 27 solution variations is grouped into three types, namely 100% porang, and 100% xanthan gum, and 50% porang - 50% xanthan gum. Compatibility testing was done after the polymer solutions were made. The solution was rejected if it was incompatible because of turbidity or sediment formation. Conversely, if the polymer solution was compatible, proceed with the viscosity and static adsorption tests. Transmittance tests and visual inspection were both used to assess the compatibility of the solutions. Meanwhile, the static adsorption test of polymer on sand used sand grains with sizes of 40 mesh and 60 mesh. Transmittance and absorption were measured using UV Vis Spectrophotometer. While viscosity was measured using Ostwald viscometer. The sandpack used acrylic material, made with dimensions of 11.8 cm × 2.7 cm × 0.76 cm (Siahaya et al., 2023). The solutions were prepared at a temperature of 60 °C, while the density, viscosity, and adsorption measurements were carried out at room temperature (27 °C).

RESULTS AND DISCUSSION

In this section, the characteristics of the experimental results of porang polymer, Xanthan gum, and porang-Xanthan gum are discussed. The discussion includes the results of testing for compatibility, viscosity, adsorption, and sandpack flooding injection.

The compatibility test is an assessment that states whether or not the polymer solution previously used is compatible (Yasahardja et al., 2017). Compatibility testing is carried out with the aim of assessing whether the polymer dissolves completely in formation water in various concentrations and salinities. The solution that has previously been stirred and mixed thoroughly is put into the bottle to observe whether it has dissolved completely and no precipitate has formed. Then, the transmittance of each solution was measured using a spectrophotometer. From the tests that have been carried out, all porang and xanthan gum polymer solutions dissolve completely and no precipitate is formed, and the transmittance value of each solution is above 50% both before and after being mixed with 40 and 60 mesh sand.

Figures 1 to 3 show the transmittance measurement results of various solutions of porang, Xanthan gum, and mixtures of porang and Xanthan gum for various concentrations and salinities. In general, all samples produced transmittance values of more than 50% both in initial conditions and after adsorption occurred due to interaction with sand.

Figure 1 shows that the transmittance of the porang solution varies between 63.4% to 90.6%. The transmittance value decreased due to increasing concentration and the adsorption process. The adsorption process was carried out by pouring polymer on sand grains. The adsorption process caused a decrease in concentration as a result of some of the polymer molecules being adsorbed on the sand surface. A decrease in polymer concentration should lead to an increase in transmittance because the concentration of the solution was reduced. The decrease in transmittance was caused by increasing turbidity due to fine grains of sand floating in the polymer solution. This was reinforced by the transmittance value of the porang solution after the adsorption process with sand grains of a finer size (60 mesh) which is lower than the transmittance value of the porang solution after adsorption with sand grains of a larger size (40 mesh). Figure 1 also shows a decrease in the transmittance value with increasing salinity of the porang solution. This is because the turbidity of the polymer solution increases with increasing salinity, so that the amount of light transmitted during transmittance measurements will decrease.

Figure 2 shows the transmittance measurement of the Xanthan gum solution. The transmittance values vary between 67.9% to 88.5%. In general, the influence of concentration, adsorption, and salinity on the transmittance of the Xanthan gum solution is directly proportional to their influence on the transmittance of the porang solution. However, the effect of salinity on changes in the transmittance of the Xanthan gum solution is smaller than the effect on the porang solution.

Figure 3 shows the transmittance measurement of porang and Xanthan gum mixture solution. The transmittance of the solution varied between 55.4% to 75.5%. The effect of salinity on changes in the transmittance of porang and Xanthan gum mixture solution as well as Xanthan gum solution is smaller than the effect of the porang solution.

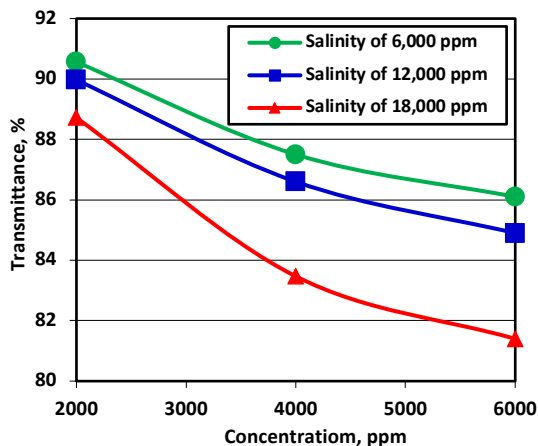
Figures 1 to 3 show a comparison of the transmittance measurement results for porang solution, Xanthan gum, and a mixture of porang and Xanthan gum. In the initial conditions, the porang solution had a transmittance value of the porang solution that was higher than the transmittance value of the Xanthan gum solution and the mixed solution of porang and Xanthan gum. Meanwhile, the smallest influence of salinity and adsorption on transmittance was in the Xanthan gum solution. However, since the transmittance is more than 50% of light and no precipitation occurs, it can be said that all porang polymer solution samples are compatible for use.

Figures 4 to 6 show the results of measuring the density of solutions of porang, Xanthan gum, and a mixture of porang and Xanthan gum. The density of polymer solution is influenced by its components, namely distilled water, NaCl, porang, and Xanthan gum. The densities of distilled water, NaCl, porang, and Xanthan gum are 0.997 g/cc, 2.16 g/cc, 0.63 gr/cc, and 1.5 g/cc respectively at 25 °C (Kirshenbaum et al., 1962; Win, 2021; Mukkun et al., 2022; Jiang et al., 2022; Xanthan gum, 2024).

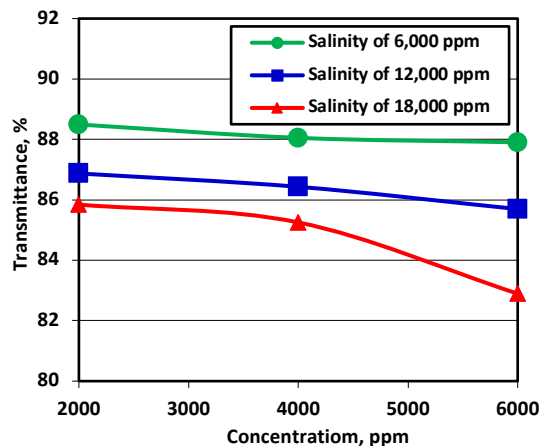
Figure 4a and 5a show that the density of the porang solution varies between 1.0536 to 1.0616 g/c and that of xanthan gum solution varies between 1.0836 to 1.0996 g/c. Meanwhile, Figure 4a and 5a show that the density of the porang solution varies between 1.0700 to 1.0872 g/c. Density tends to increase with increasing concentration and salinity. On the other hand, the density of the porang solution decreases due to adsorption. The interaction and binding of dissolved solid molecules on the sand surface results in a reduction in the concentration of dissolved substances and a decrease in the density of the solution. Figures 4b and 4c show that the density tends to decrease with decreasing sand grain size from 40 mesh to 60 mesh. A pile of sand with a smaller grain size has a larger surface area for the same weight. So that a smaller sand grain size causes a higher adsorption level.

Figures 7 to 9 show the viscosity of porang, Xanthan gum, and a mixture of porang and Xanthan gum solutions for various concentrations and salinities before and after adsorption. Figures 7 to 9 show that

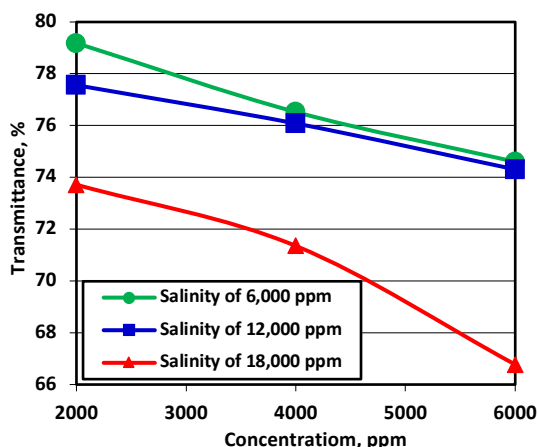
increasing salinity causes a decrease in viscosity values. The viscosity of the porang solution at initial conditions is shown in Figure 7a. The decrease in viscosity from 6000 ppm to 18000 ppm salinity varies from 20.1% to 31.2%. The viscosity of the Xanthan gum solution at initial conditions is shown in Figure 8a. The reduction in viscosity from 6000 ppm to 18000 ppm salinity varies from 19.7% to 20.9%. Meanwhile, the viscosity of the mixture of porang and Xanthan gum at initial conditions is shown in Figure 9a. The decrease in viscosity from 6000 ppm to 18000 ppm salinity varies from 22.6% to 27.3%.



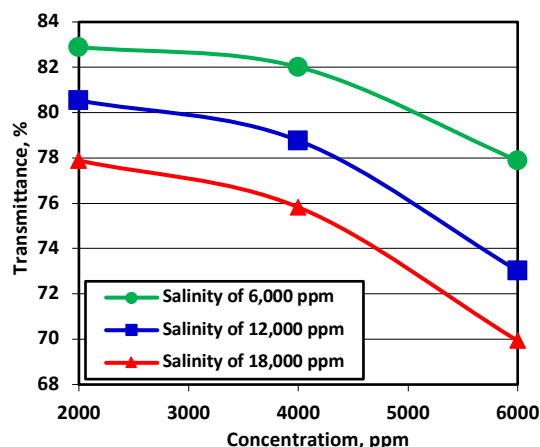
A. at initial condition



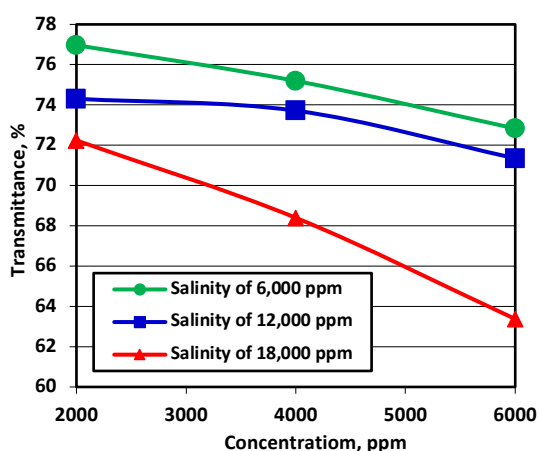
A. at initial condition



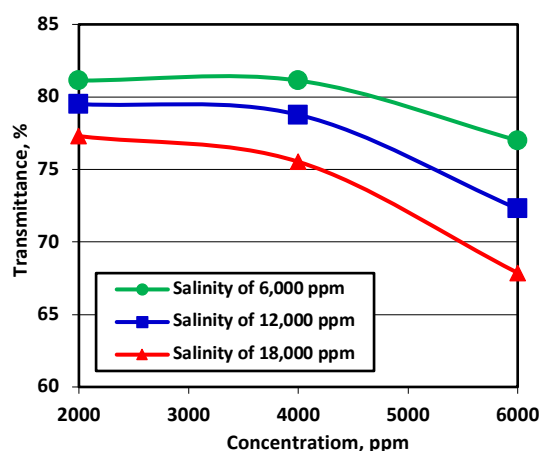
B. After adsorption with 40 mesh sand grains



B. After adsorption with 40 mesh sand grains



C. After adsorption with 60 mesh sand grains

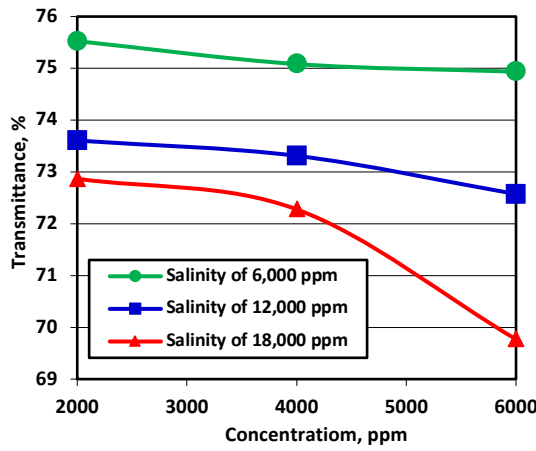


C. After adsorption with 60 mesh sand grains

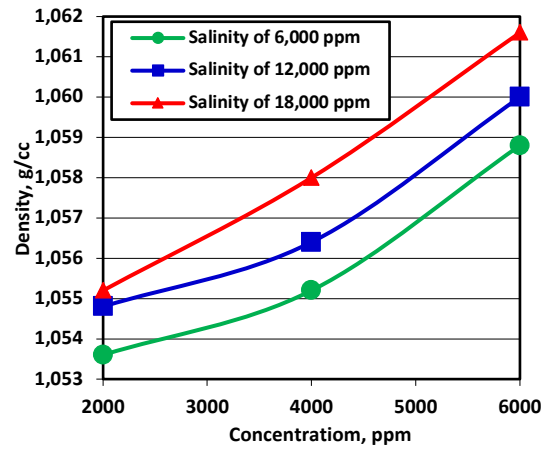
Figure 2. Results of transmittance measurements of porang solution before and after adsorption for various salinities.

Figure 3. Results of transmittance measurements of Xanthan gum solution before and after adsorption for various salinities.

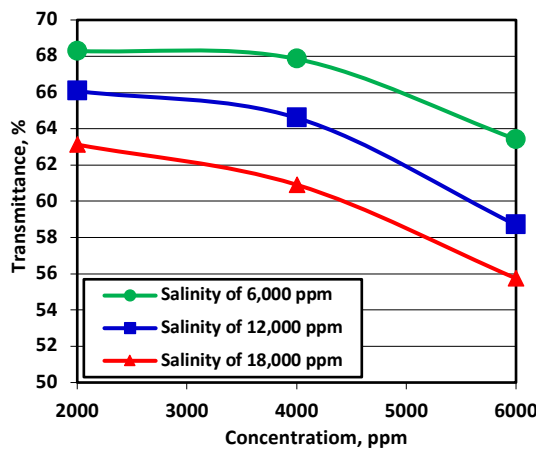
Porang and xanthan gum have the ability to bind water. The maximum water adsorption capacity of porang is 2006 mg/g, higher than xanthan gum which is only 521.0 mg/g. This adsorption causes gel formation and increased viscosity (Lestari et al., 2016; Makhado et al., 2017). On the other hand, gel formation can cause polymer retention and affect sweeping efficiency.



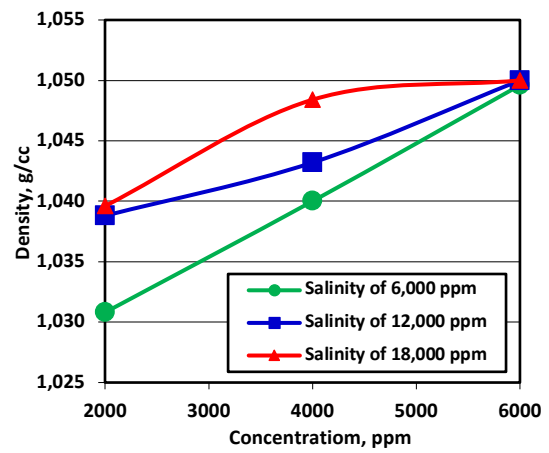
A. at initial condition



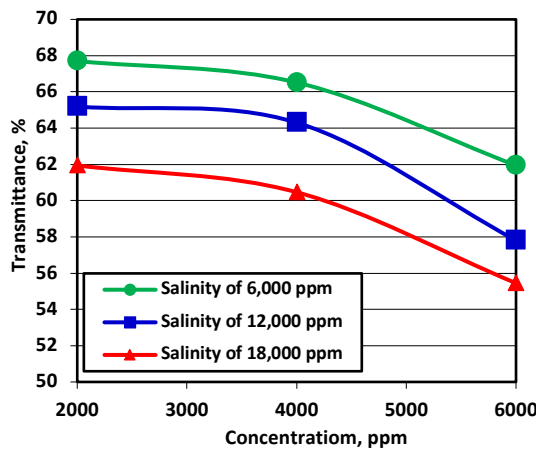
A. at initial condition



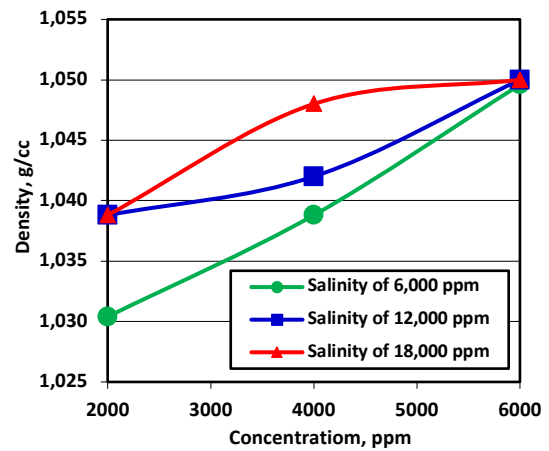
B. After adsorption with 40 mesh sand grains



B. After adsorption with 40 mesh sand grains



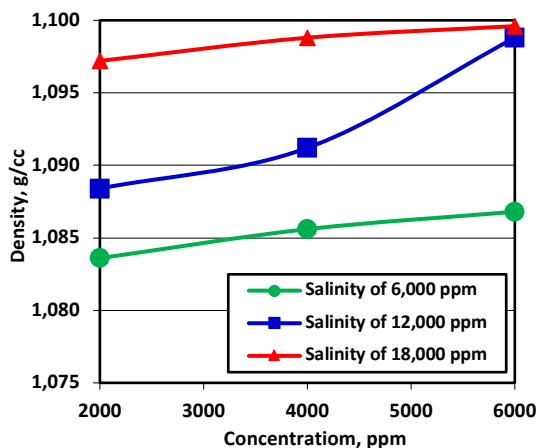
C. After adsorption with 60 mesh sand grains



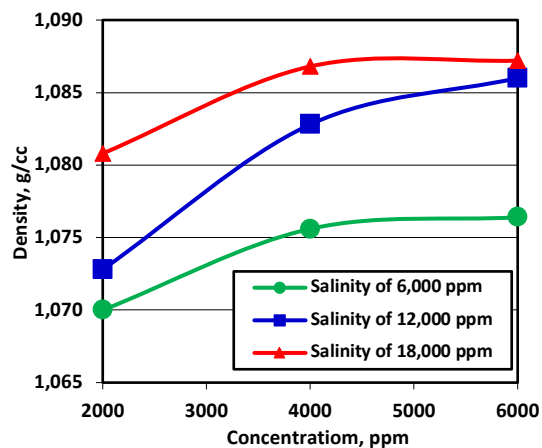
C. After adsorption with 60 mesh sand grains

Figure 4. Results of transmittance measurements of porang-Xanthan gum mixture solution before and after adsorption for various salinities.

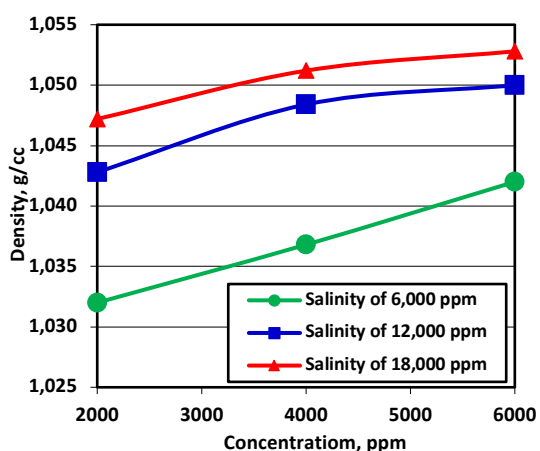
Figure 5. Results of density measurements of porang solution before and after adsorption for various salinities.



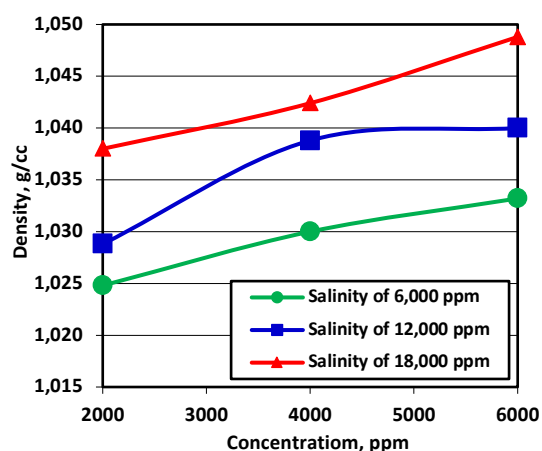
A. at initial condition



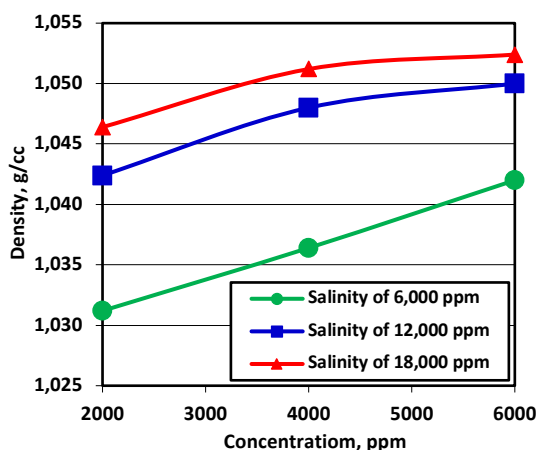
A. at initial condition



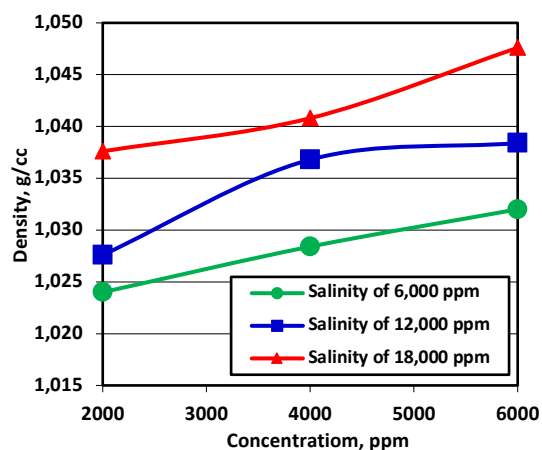
B. After adsorption with 40 mesh sand grains



B. After adsorption with 40 mesh sand grains



C. After adsorption with 60 mesh sand grains



C. After adsorption with 60 mesh sand grains

Figure 6. Results of density measurements of Xanthan gum solution before and after adsorption for various salinities.

Figure 7. Results of density measurements of porang-Xanthan gum mixture solution before and after adsorption for various salinities.

The addition of NaCl levels will shorten the polymer chains so that the viscosity decreases, while with increasing concentration values of the polymer solution the viscosity values also increase. These results support previous research which stated that the higher the polymer concentration value, the higher the viscosity value of the polymer solution and the higher the salinity value, the lower the viscosity value of the resulting polymer solution (Afdi, 2022; Frigrina et al., 2017; Ulfah, 2023). The effect of adsorption on the viscosity of the porang solution is shown in Figure 7. The reduction in viscosity after adsorption on 40 mesh sand (Figure 7b) varies from 9.1% to 28.3%. Meanwhile, the decrease in viscosity after adsorption on 60 mesh sand (Figure 7c) varies from 18.4% to 34.8%.

The effect of adsorption on the viscosity of the Xanthan gum solution is shown in Figure 8. The reduction in viscosity after adsorption on 40 mesh sand (Figure 8b) varies from 22.5% to 45.3%. Meanwhile, the decrease in viscosity after adsorption on 60 mesh sand (Figure 8c) varies from 27.8% to 49.1%. The effect of adsorption on the viscosity of the mixed solution of porang and Xanthan gum is shown in Figure 9. The reduction in viscosity after adsorption on 40 mesh sand (Figure 9b) varied from 18.9% to 46.4%. Meanwhile, the decrease in viscosity after adsorption on 60 mesh sand (Figure 9c) varies from 11.8% to 51.6%. After the adsorption process, the viscosity decreases, because some of the polymer particles are adsorbed on the rock surface so that the polymer concentration in the solution is reduced. In addition, based on these results, it shows that the effect of adsorption on the Xanthan gum solution causes a higher percentage reduction in viscosity than the reduction in viscosity due to adsorption on the porang solution.

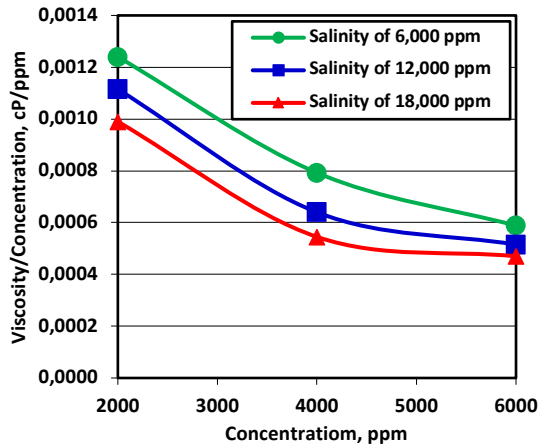
Tables 1 to 3 respectively show the results of adsorption measurements of Xanthan gum, porang solution and a mixture of porang and Xanthan gum with salinities of 6000 ppm, 12000 ppm, and 18000 ppm on sand grains with sizes of 40 mesh and 60 mesh. In general, increasing the polymer concentration causes an increase in the adsorbed polymer. The explanation for the increase in adsorption with increasing concentration can be attributed to the increased availability of polymer molecules, which happen to be adsorbed on the rock surface. polymer molecules are expected to be adsorbed on the rock surface through hydrogen bonds generated between the hydrogens of the hydroxyl groups in the polymer and the negatively charged the surface of sand grains (Azmi et al., 2022).

Tables 1 to 3 also show that increasing salinity causes an increase in polymer adsorption. The compression of the double layer as a result of the increased ionic strength of the solution causes an increase in adsorption along with an increase in NaCl content. This makes it easier for the polymer to get closer to the solid surface (Figdore, 1982; Paternina et al., 2020). In addition, the increase in the adsorption value when increasing the NaCl concentration can be attributed to the polymer salting-out effect. The salting-out effect caused a decrease in the polymer solubility leading to polymer precipitation and hence an increase in the adsorption (Azmi et al., 2022). Furthermore, Tables 1 to 3 show that the number of polymer particles adsorbed on 60 mesh sand grains is greater than 40 mesh. Adsorption on 60 mesh sand is greater than 40 mesh sand because the total surface area of small grains (60 mesh) for the same weight of sand pile is wider than large grains (40 mesh). The adsorption phenomenon causes the viscosity and density of the solution to decrease.

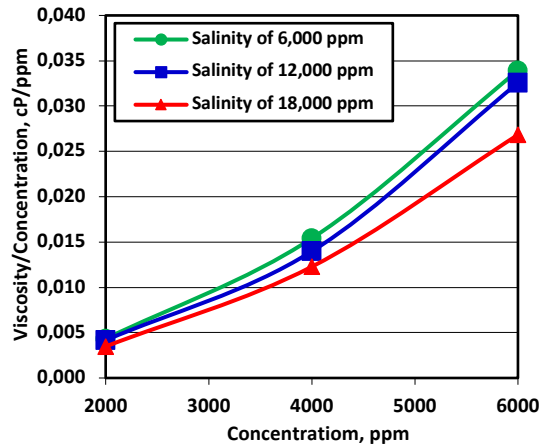
Comparison of Tables 1 and 2 shows that the adsorption of the porang is lower than the adsorption of Xanthan gum. Xanthan gum is likely to be more adsorbed onto sand grains than glucomannan from *Amorphophallus oncophyllus*. This is due to xanthan gum's more favorable interactions with the hydrophilic silica surface of sand, its ability to form strong hydrogen bonds, and its more compact, branched structure, which can more easily anchor to the surface. In contrast, glucomannan, while also hydrophilic, forms a gel-like structure that may surround sand grains rather than strongly adsorb onto them, leading to lower adsorption compared to xanthan gum (Mao et al., 2012; Azmi et al., 2022; Zhang et al., 2016).

Comparison of Tables 2 and 3 shows that the adsorption of the mixture of porang and Xanthan gum is lower than the adsorption of Xanthan gum. The interaction between porang and xanthan molecules must be the cause of this phenomenon. The precise mechanism of this relationship was genuinely unclear, according to Morris (1998). Several mechanism models were proposed for gelation, including: (1) glucomannan backbone binding to xanthan helix, (2) glucomannan backbone combined with the free cellulosic face of the backbone of the denatured xanthan helix, (3) xanthan deacetylation in xanthan-konjac mannan mixtures, which improved xanthan-konjac mannan gelation, and (4) heating that broke up aggregated xanthan chains, allowing for interaction with glucomannan, etc. The specifics of the interaction between xanthan gum and konjac flour are still up for dispute, though (Akesowan, 2002).

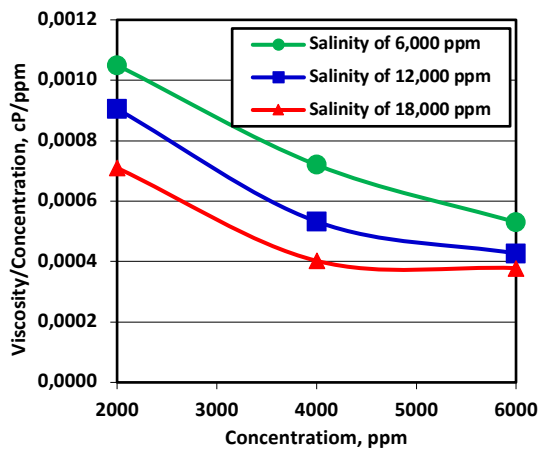
The addition of porang to the Xanthan gum polymer could reduce the adsorption value. The highest adsorption reduction was found in a solution sample with a concentration of 6,000 ppm and a salinity of 18,000 ppm with an adsorption reduction value of 3.545 mg/gr. The polymer solution condition was in contact with 40 mesh sand grains.



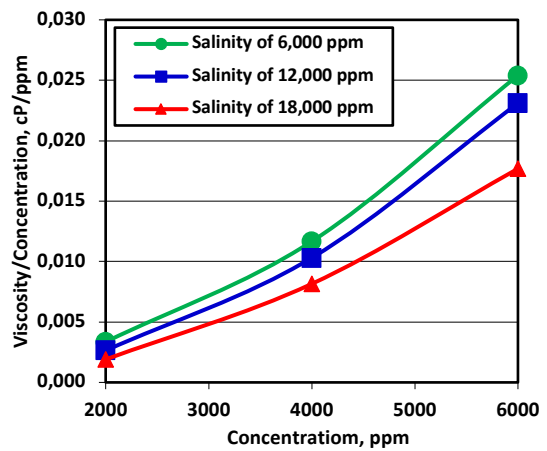
A. at initial condition



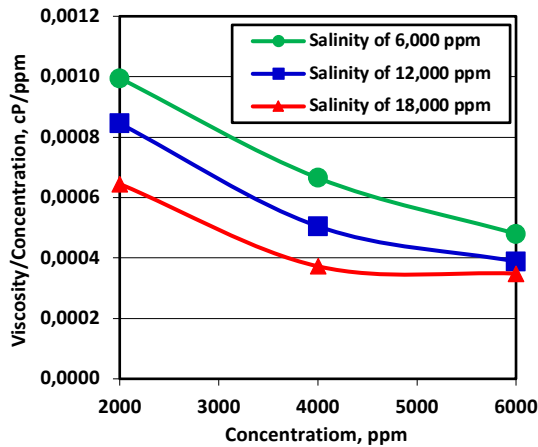
A. at initial condition



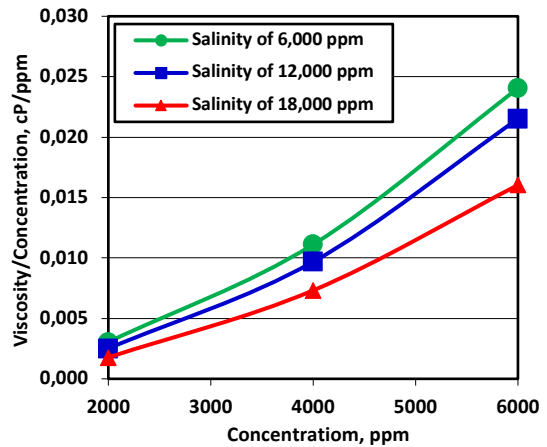
B. After adsorption with 40 mesh sand grains



B. After adsorption with 40 mesh sand grains



C. After adsorption with 60 mesh sand grains



C. After adsorption with 60 mesh sand grains

Figure 8. Results of viscosity measurements of porang solution before and after adsorption for various salinities.

Figure 9. Results of viscosity measurements of Xanthan gum solution before and after adsorption for various salinities.

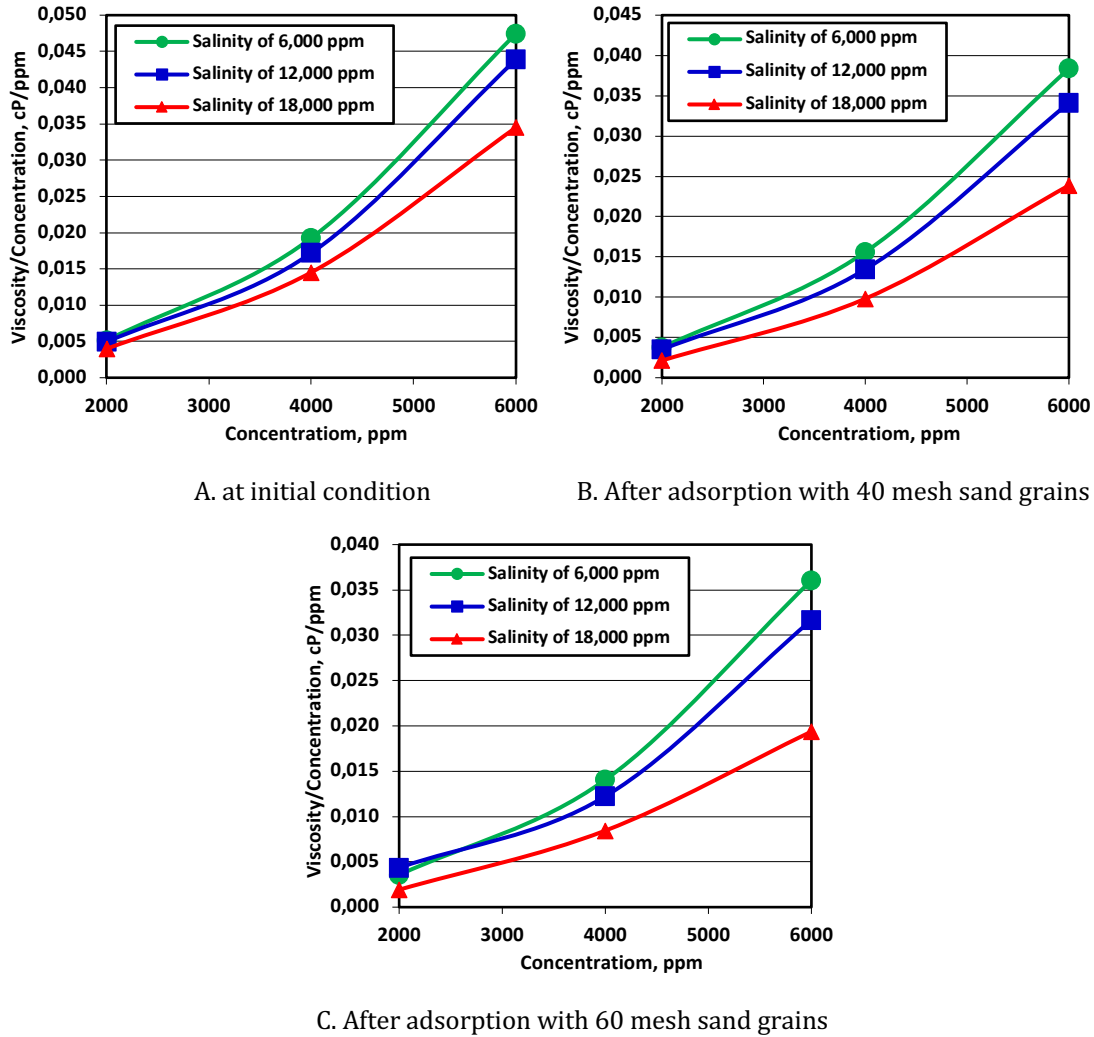


Figure 10. Results of viscosity measurements of Xanthan gum solution before and after adsorption for various salinities.

Table 1. Results of adsorption measurements of porang solution for various salinities.

| No. | Salinity, ppm | Concentration, ppm | Equilibrium concentration C_e , mg/g | | Adsorbed polymer Q_e , mg/g | |
|-----|---------------|--------------------|--|---------|-------------------------------|---------|
| | | | 40 mesh | 60 mesh | 40 mesh | 60 mesh |
| 1 | 6000 | 2000 | 1302.5 | 396.7 | 1.744 | 4.008 |
| 2 | 6000 | 4000 | 2936.6 | 1764.4 | 2.658 | 5.589 |
| 3 | 6000 | 6000 | 4712.8 | 3149.8 | 3.218 | 7.126 |
| 4 | 12000 | 2000 | 969.9 | 85.9 | 2.575 | 4.785 |
| 5 | 12000 | 4000 | 2664.2 | 1651.3 | 3.339 | 5.872 |
| 6 | 12000 | 6000 | 4469.0 | 3014.1 | 3.828 | 7.465 |
| 7 | 18000 | 2000 | 629.3 | 49.8 | 3.427 | 4.875 |
| 8 | 18000 | 4000 | 2348.9 | 1563.9 | 4.128 | 6.090 |
| 9 | 18000 | 6000 | 4218.1 | 2722.7 | 4.455 | 8.193 |

Table 2. Results of adsorption measurements of Xanthan gum solution for various salinities.

| No. | Salinity, ppm | Concentration, ppm | Equilibrium concentration C_e , mg/g | | Adsorbed polymer Q_e , mg/g | |
|-----|---------------|--------------------|--|---------|-------------------------------|---------|
| | | | 40 mesh | 60 mesh | 40 mesh | 60 mesh |
| 1 | 6000 | 2000 | 1067.7 | 286.5 | 2.331 | 4.284 |
| 2 | 6000 | 4000 | 2630.2 | 1849.0 | 3.424 | 5.378 |
| 3 | 6000 | 6000 | 3724.0 | 2786.5 | 5.690 | 8.034 |
| 4 | 12000 | 2000 | 1026.9 | 218.9 | 2.433 | 4.453 |
| 5 | 12000 | 4000 | 2390.6 | 1330.0 | 4.024 | 6.675 |
| 6 | 12000 | 6000 | 3552.2 | 2441.1 | 6.120 | 8.897 |
| 7 | 18000 | 2000 | 830.2 | 113.2 | 2.925 | 4.717 |
| 8 | 18000 | 4000 | 1924.5 | 1283.0 | 5.189 | 6.792 |
| 9 | 18000 | 6000 | 2943.4 | 2188.7 | 7.642 | 9.528 |

Table 3. Results of adsorption measurements of porang & Xanthan gum solution for various salinities.

| No. | Salinity, ppm | Concentration, ppm | Equilibrium concentration C_e , mg/g | | Adsorbed polymer Q_e , mg/g | |
|-----|---------------|--------------------|--|---------|-------------------------------|---------|
| | | | 40 mesh | 60 mesh | 40 mesh | 60 mesh |
| 1 | 6000 | 2000 | 1385.4 | 479.6 | 1.536 | 3.801 |
| 2 | 6000 | 4000 | 3055.1 | 1953.8 | 2.362 | 5.115 |
| 3 | 6000 | 6000 | 4760.2 | 3552.4 | 3.099 | 6.119 |
| 4 | 12000 | 2000 | 1221.6 | 208.7 | 1.946 | 4.478 |
| 5 | 12000 | 4000 | 2860.7 | 1718.8 | 2.848 | 5.703 |
| 6 | 12000 | 6000 | 4518.1 | 3376.3 | 3.705 | 6.559 |
| 7 | 18000 | 2000 | 1071.7 | 174.5 | 2.321 | 4.564 |
| 8 | 18000 | 4000 | 2735.2 | 1613.7 | 3.162 | 5.966 |
| 9 | 18000 | 6000 | 4364 | 3034.3 | 4.097 | 7.414 |

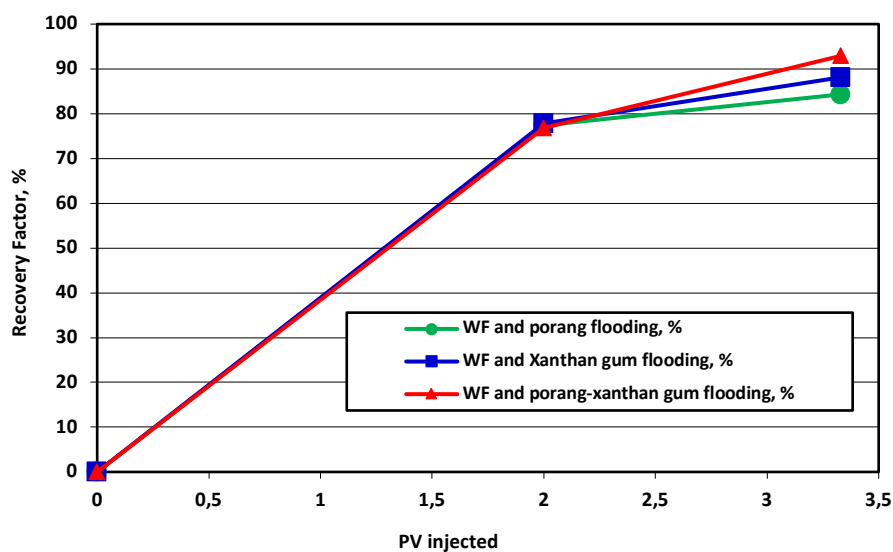


Figure 10. Oil recovery by waterflooding followed by polymer flooding.

Table 4. Characteristics and performance of waterflooding and polymer flooding.

| Parameter | Solution | | |
|-------------------|----------|-------------|------------------------|
| | Porang | Xanthan gum | Porang and Xanthan gum |
| PV, cc | 15.0 | 14.9 | 15.2 |
| ϕ , % | 60.9 | 60.5 | 61.7 |
| OOIP, cc | 10.6 | 11.3 | 11.2 |
| Soi, % | 70.7 | 75.8 | 73.7 |
| $N_{p_{wf}}$, cc | 8.2 | 8.7 | 8.6 |
| RF_{wf} , % | 77.4 | 77.8 | 76.8 |
| $N_{p_{pf}}$, cc | 0.73 | 1.4 | 1.8 |
| RF_{pf} , % | 6.9 | 10.3 | 16.1 |

The sandpack flooding test was carried out to see the results of oil pressure by formation water and the selected polymer solution. The solution is selected from each type of solution based on the highest viscosity value. The selected solutions of porang (P), Xanthan gum (X), and a mixture of porang and Xanthan gum (PX) respectively have viscosities of 3.53 cP, 203.49 cP, and 284.72 cP. The characteristics and performance of water flooding of 2 PV followed by Polymer Flooding of 1.33 PV are shown in Table 4 and Figure 10. The oil recovery factor (RF) produced by Water Flooding varies from 76.8% to 77.8%. Meanwhile, the oil recovery factor with porang solution, Xanthan gum, and a mixture of porang and the mixture of porang and Xanthan gum after waterflooding respectively provided additional RF of 6.9%, 10.3% and 16.1%. Based on a comparison of these results, the flood polymer using a mixture of porang and Xanthan gum has the highest viscosity value and provides the highest additional RF. This is in line with previous research, namely that polymer injection can increase oil recovery due to an increase in the viscosity value of the pressing fluid to increase sweeping efficiency (Adianto, 2022; Afdi, 2022; Rita, 2012; Sydansk & Zeron, 2011; Ulfah, 2023).

CONCLUSION

Based on the research results obtained from laboratory experimental testing of porang and xanthan gum solutions, it can be concluded as follows. Based on the results of the compatibility test, all samples of porang, xanthan gum and porang-xanthan gum solutions tested had no sediment and the transmittance value was more than 50%. All samples are compatible with formation water salinities of 6,000 ppm, 12,000 ppm and 18,000 ppm with varying concentrations of 2,000 ppm, 4,000 ppm and 6,000 ppm. Based on the results of the viscosity test, the addition of porang, xanthan gum, and a mixture of porang and xanthan gum can increase the viscosity value of the two polymers. The highest viscosities of porang, xanthan gum, and a mixture of porang and xanthan gum were 3.53 cP, 203.49 cP, and 284.72 cP, respectively. Based on the results of the adsorption test, the addition of porang to the Xanthan gum polymer can reduce the adsorption value, with the highest decrease in adsorption value, namely 3.545 mg/gr in a mixed solution of porang and mesh. Based on the results of the sandpack flooding test, the addition of porang to Xanthan gum produces the highest incremental recovery factor value, namely 16.1%. For application in EOR projects in oil reservoirs, several things such as the interaction between porang with fluids and reservoir rocks and the effect of temperature need to be observed in the development of this research because the polymer is quite sensitive, so that porang can function well.

NOMENCLATURE

| | |
|--------------|---|
| PV | = pore volume, cc |
| ϕ | = porositas, % |
| $N_{p_{pf}}$ | = cumulative oil produced due to polymer flooding, cc |
| $N_{p_{wf}}$ | = cumulative oil produced due to water flooding, cc |
| OOIP | = original oil in place, cc |
| RF_{pf} | = recovery factor due to polymer flooding, % |
| RF_{wf} | = recovery factor due to water flooding, % |
| Soi | = initial oil saturation, % |

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