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Full-Set Measurements Dataset for a Water-Based Drilling Fluid Utilizing Biodegradable Environmentally Friendly Drilling Fluid Additives Generated from Waste

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Data Article

Full-set measurements dataset for a water-based drilling fluid utilizing biodegradable environmentally friendly drilling fluid additives generated from waste

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ABSTRACT

The oil and gas industry is moving towards more environmentally friendly practices. The environmental regulations regarding drilling waste management and disposal are motivating the industry to be more efficient with drilling operations. Environmentally friendly drilling fluid additives used in drilling operations reduces not only the negative implications on the environment but also reduces costs. This paper provides an experimental dataset of utilizing biodegradable waste materials as environmentally friendly drilling fluid additives. The data were collected through experimental evaluations of several waste materials including Potato Peels Powder (PPP), Mandarin Peels Powder (MPP), Fibrous Food Waste Material (FFWM), Palm Tree Leaves Powder (PTLP), Grass Powder (GP), and Green Olive Pits' Powder (GOPP). The data presented herein are the raw results of the experiments, which were conducted to examine the ability of the biodegradable waste materials to improve the water-based drilling fluids. The data include the effects of adding these waste materials on different drilling fluid properties such as mud weight, filtration, pH, and the rheology. The mud weight was measured using mud balance, the filtration data were collected using API filter press for both low/high pressure and temperature, the pH was measured using pH meter, and the rheology was characterized using viscometer. The

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dataset is potentially useful to assist researchers working on developing environmentally friendly drilling fluid additives.

Specifications Table

Subject	Waste Management and Disposal
Specific subject area	Drilling fluid characteristics for water-based mud
Type of data	Table
How data were acquired	Experimental measurements using various equipment such as Electronic Analytical Balance, pH Meter, Mud Mixer, Mud Balance, LTLP Filter Press, HTHP Filter Press, Model 800 Viscometer, Marsh Funnel Viscometer, Digital and Manual Vernier Calipers, Resistivity Meter, Chemical Titration, Retort Kit, Aged Cell and Accessories, and Roller Oven and Accessories
Data format	Raw
Experimental factors	Various properties of water-based drilling mud samples at different temperatures and pressures have been studied
Experimental features	In summary, all the experimental studies indicated that biodegradable and environmentally friendly waste products can be exploited as an alternative or supportive additive to conventional drilling fluid chemicals
Data source location	Missouri University of Science and Technology Missouri, Rolla, United States
Data accessibility	With the article

Value of the Data

- The focal point of this data is to recognize various eco-friendly waste materials and how they can be exploited in drilling operations, particularly in drilling fluids.
- The data are useful because using eco-friendly additives in drilling fluid is a limited topic in the literature and due to strict environmental regulations, oil companies are shifting to use more environmentally friendly additives to reduce the effect on the environment and cost.
- The data will benefit any interested researchers who want to further investigate the use of eco-friendly waste materials in the drilling operation or other oil and gas-related applications.
- The data in this article will serve as a base for future researchers on the subject of utilizing biodegradable wastes in the petroleum industry. The researchers will be able to test different waste materials under different temperatures and aging conditions. Finally, once these materials prove their potential under hostile environments, they can be tested and applied in the oilfield.

1. Data

The data presented in this work were collected from the experimental investigation of utilizing biodegradable environmentally friendly drilling fluid additives generated from waste. Several food wastes were investigated and full-set measurements of adding these wastes to the drilling fluid were conducted.

Several researchers have studied food wastes as drilling fluids additives including but not limited to banana peels, potato peels, Arabic gum, olive pulp, corncob, corn starch, pomegranate powder, peach pulp, tamarind gum, soya bean, coconut coir, sugar cane, grass, henna powder, rice husk, cashew, and mango extracts [1–8]. The enhancement of the properties of the drilling fluid was observed by all of those researchers.

In this work, Table 1 lists the data of the Potato Peels Powder (PPP) 9. Table 2 shows the data for Mandarin Peels Powder (MPP) [10]. Tables 3 and 4 show the data for Fibrous Food Waste Material (FFWM) [11]. Tables 5 and 6 show the data for Palm Tree Leaves Powder (PTLP) [12]. Table 7 shows the data for Grass Powder (GP) [13]. Table 8 shows the data for Green Olive Pits' Powder (GOPP) [14].

Table 1
Effect of variation in the concentration of the PPP on the properties of water-based mud.

Property	RF	1% PPP	2% PPP	3% PPP	4% PPP
Mud Density, (ppg)	8.6	8.6	8.62	8.64	8.65
Plastic Viscosity (PV), (cp)	7	7	8	9	10
Yield Point (YP), ($Ib/100ft^2$)	11	7	6	6	6
Initial Gel Strength, ($Ib/100ft^2$)	12	9	8	8	8
Final Gel Strength, ($Ib/100ft^2$)	17	13	12	12	12
pH	10	8.4	8.2	8.1	7.9
Mud Resistivity, (ohms-mt)	7	5	4	3.75	3.4
Mud Temperature, (°F)	73	73	73	73	73
Mud NaCl Concentration, (ppm) (nomograph)	750	1100	1350	1500	1650
30 min Filtrate, (cc)	12.5	11	10	9	8.75
Filter Cake Thickness, (mm)	3	1.7	1.75	1.8	1.8
Filter Cake Thickness (mm) * (32/25.4), (1/32 inch)	3.78	2.14	2.21	2.26	2.26
Filter Cake Resistivity, (ohm-mt)	2.1	1.6	1.5	1.3	1.1
Filter Cake NaCl Concentration, (ppm) (nomograph)	2700	3700	3900	4500	5200
Pf, (cc)	0.6	0.1	0.07	0.05	0.02
Mf, (cc)	1	0.3	0.35	0.4	0.5
Pm, (cc)	0.7	0.05	0.04	0.02	0.01
Ca^{++}, (mg/l)	40	8	8	6	6
NaCl, (mg/l) (ppm)	182	324	578	625	775
% by Vol. Solids (S.C)	1	1	1	2	2

Table 2
Effect of adding various concentration of MPP and PAC-LV on the properties of reference fluid.

Property	RF	1% MPP	1% PAC-LV	2% MPP	2% PAC-LV	3% MPP	3% PAC-LV	4% MPP	4% PAC-LV
Mud Density, (ppg)	8.6	8.4	8.6	8.2	8.4	8	8.35	8	8.35
PV, (cp)	7	14	25	24	52	38	69	63	None
YP, ($Ib/100ft^2$)	11	14	26	17	68	33	109	57	None
Initial Gel Strength, ($Ib/100ft^2$)	12	10	15	10	37	12	55	24	110
Final Gel Strength, ($Ib/100ft^2$)	17	14	36	14	68	17	99	28	185
pH	10	8	9.7	7.7	9.3	7	9.3	6.8	9.2
Mud Resistivity, (ohms-mt)	7	5.8	5.5	5.2	4	5	3	4.8	2.2
Mud Temperature, (°F)	73	76	74	76	76	76	82	74	84
Mud NaCl, (ppm)	750	900	950	1000	1300	1050	1600	1100	2200
7.5 min Filtrate, (cc)	6	3.5	3	2.75	2.5	2	2	1.75	1.75
30 min Filtrate, (cc)	12.5	7	6	6	5	4.5	4.5	4	3.75
Filter Cake Thickness, (mm)	3	1.6	1.9	1.4	2.2	1.35	2.3	1.35	2.5
Filter Cake Resistivity, (ohm-mt)	2.1	1.3	0.85	0.85	0.71	0.77	0.4	0.77	0.32
Filter Cake Temperature, (°F)	73	72	74	74	76	74	84	74	78
Filter Cake NaCl, (ppm)	2700	4500	6600	7000	8000	7500	13000	7500	18500
Ca^{++}, (mg/l)	40	4	8	4	12	4	12	4	12
NaCl, (mg/l) (ppm)	182	247.5	330	330	450	330	495	330	660

Table 3
Effect of variation in the concentration of the FFWM on the properties of water-based mud (pH = 9.3).

Property	RF	1% FFWM	2% FFWM
Mud Density, (ppg)	8.6	8.6	8.6
PV, (cp)	6	8	8
YP, ($Ib/100ft^2$)	9	11	13
Initial Gel Strength, ($Ib/100ft^2$)	8	11	13
Final Gel Strength, ($Ib/100ft^2$)	14	15	16
30 min Filtrate, (cc)	12.5	10.25	8.75
Filter Cake Thickness, (mm)	3	2.4	1.9
Filter Cake Thickness (mm) * (32/25.4), (1/32 inch)	3.8	3	2.4

Table 4
Effect of variation in the concentration of the FFWM on the properties of water-based mud (pH = 11.5).

Property	1% FFWM	2% FFWM
Mud Density, (ppg)	8.6	8.6
PV, (cp)	8	9
YP, (Ib/100ft^2)	15	17
Initial Gel Strength, (Ib/100ft^2)	17	18
Final Gel Strength, (Ib/100ft^2)	25	27
30 min Filtrate, (cc)	8.5	7
Filter Cake Thickness, (mm)	1.8	1.8
Filter Cake Thickness (mm) * (32/25.4), (1/32 inch)	2.26	2.26

Table 5
Effects of adding various concentrations of PTLP to the reference fluid (fresh conditions).

Property	RF	1.5% PTLP	3% PTLP
Plastic Viscosity (PV), (cp)	8	9	12
Yield Point (YP), (Ib/100ft^2)	12	5	5
Initial Gel Strength, (Ib/100ft^2)	15	6	7
Final Gel Strength, (Ib/100ft^2)	20	11	12
pH	11	8.8	8
7.5 min Filtrate, (cc)	6	4	3.25
30 min Filtrate, (cc)	12.5	9.25	8.5
Filter Cake Thickness, (mm)	3	1.9	2

Table 6
Effects of adding various concentrations of PTLP to the reference fluid (aged conditions).

Property	1.5% PTLP	3% PTLP
Plastic Viscosity (PV), (cp)	9	9
Yield Point (YP), (Ib/100ft^2)	6	5
Initial Gel Strength, (Ib/100ft^2)	6	6
Final Gel Strength, (Ib/100ft^2)	12	11
pH	8.7	8.1
7.5 min Filtrate, (cc)	4.25	4
30 min Filtrate, (cc)	9.5	9
Filter Cake Thickness, (mm)	2	2

2. Experimental design, materials, and methods

This section was broken into various sub-sections in order to provide a solid image and coherent insight regarding the performances of each environmentally friendly waste material. Hence, a summary of all the findings for the various bio-enhancers drilling fluid additives at different concentrations and conditions were introduced and tabulated as well as the experimental design and testing matrix.

2.1. Experimental investigation data of Potato Peels Powder (PPP)

First of all, the spud mud sample (freshwater bentonite) referred to as the base mud (or reference fluid) was prepared using 600 cc of water, 0.6 g of NaOH, and 36 g of bentonite. Four samples of drilling fluid were prepared by mixing 1% concentration (6 g) of PPP, then the concentrations of PPP for the other three samples were increased to 2% (12 g), 3% (18 g), and 4% (24 g) to minutely understand the impact of concentration variation on the reference mud. Standard API drilling fluids testing equipment such as rheometer/viscometer, pH meter and temperature, filter press, mud balance, resistivity device, retort kit, and various chemical titrations have been used in order to evaluate the effectiveness of potato peels powder (PPP) to water-based mud in terms of adding various concentrations. All these

Table 7
Effect of variation in the concentration of the GP and starch on the reference fluid properties of water-based mud.

Property	RF	0.5% GP	0.5% Starch	1% GP	1% Starch	1.5% GP	1.5% Starch
Mud Density, (ppg)	8.6	8.6	8.6	8.6	8.6	8.5	8.55
Marsh Funnel Viscosity, (Sec.)	33	41	46	44	56	49	67
PV, (cp)	8	9	10	9	12	13	17
YP, (Ib/100ft^2)	17	19	22	20	27	25	36
Initial Gel Strength, (Ib/100ft^2)	12	20	21	22	23	26	39
Final Gel Strength, (Ib/100ft^2)	24	25	33	26	35	33	50
pH	11	9.4	10.4	9.2	10.3	8.7	9.9
Mud Resistivity, (ohms-mt)	7	4	5.5	3.5	4	3	3.2
Mud Temperature, (°F)	77	77	77	77	77	77	77
Mud NaCl Concentration, (ppm)	750	1300	900	1400	1150	1850	1550
7.5 min Filtrate, (cc) (LTLP)	6	3.5	4	3.5	3.25	3	2.75
30 min Filtrate, (cc) (LTLP)	12.5	7.25	9	7	7.5	6.25	6
Filter Cake Thickness, (mm) (LTLP)	3	2	2.6	2	2.4	2.5	2.8
7.5 min Filtrate, (cc) (HTHP)	19	13	18	11.5	13	10.5	11
30 min Filtrate, (cc) (HTHP)	35	26	34	23	27	20	23
Filter Cake Thickness, (mm) (HTHP)	4.9	3.4	5.4	3.5	5	4.7	6.5
Filter Cake Resistivity, (ohm-mt)	2.1	0.51	0.82	0.4	0.5	0.34	0.41
Filter Cake Temperature, (°F)	77	77	77	77	77	77	77
Filter Cake NaCl Concentration, (ppm)	2700	11000	6500	14000	12300	17000	14250
Ca^{++}, (mg/l)	50	14	50	14	50	8	50
Filtrate NaCl Concentration, (ppm)	182	577	330	825	495	990	660
% by Vol. Solids (S.C)	1	1	1	1	1	1	

Table 8
Impact of variation in the concentration of green olive pits' powder (GOPP) on the specifications of water-based mud.

Property	RF	0.75% GOPP	1.5% GOPP
Mud Density, (ppg)	8.6	8.6	8.5
Plastic Viscosity (PV), (cp)	5	6	7
Yield Point (YP), (Ib/100ft^2)	11	30	26
Initial Gel Strength, (Ib/100ft^2)	12	23	20
Final Gel Strength, (Ib/100ft^2)	17	31	29
pH	9.7	8.5	8.1
7.5 min Filtrate, (cc)	6	5	5.5
30 min Filtrate, (cc)	12	10	11.5
Filter Cake Thickness, (mm)	2.6	2.4	3

tests were conducted under the surface conditions to obtain the physical and chemical properties of the mud as shown in Table 1 [9].

2.2. *Experimental investigation data of Mandarin Peels Powder (MPP)*

The reference fluid (RF) sample was spud mud type and prepared using only bentonite and NaOH as conventional chemical additives. The composition of the spud mud sample was 600 cc of water, 0.6 g of caustic soda, and 36 g of bentonite. Different concentrations of MPP and PAC-LV ranging between 1% by weight (6 g) to a maximum of 4% by weight (24 g) were used and added separately to the reference mud, then to evaluate the effect of adding the different concentrations of MPP and PAC-LV on the reference mud, full-set measurements were initially addressed for the reference mud, then the same measurements were conducted after adding MPP and PAC-LV. The tests included rheological properties, filtration characteristics, and mud weight. Rheological properties including; plastic viscosity (PV), yield point (YP), initial and final gel strength, were conducted using rotary viscometer. The filtration characteristics including; fluid loss in cc/30min and the filter cake thickness were obtained using the standard API filter press at 100 psi. While the mud weight was determined using mud balance. The data are shown in Table 2 [10].

2.3. Experimental investigation data of Fibrous Food Waste Material (FFWM)

To recognize the impact of adding various concentrations of FFWM on the properties of the drilling mud, the reference fluid (RF) was initially prepared, and it consisted of 1000 cc of water, 0.6 gm of NaOH, and 60 gm of bentonite. Then, full-set measurements were conducted and recorded to the reference fluid in order to be compared to the effects of adding FFWM. For instance, mud weight was conducted utilizing the mud balance; while the rheological properties including; the plastic viscosity, yield point, initial gel strength for 10 seconds, and the final gel strength for 10 minutes were determined using the rotary viscometer. The filtration characteristics including the fluid loss in cc/30min and the filter cake thickness were measured using the standard API Filter Press at 100 psi (LTLP).

The data of this experiment were classified based on one pH condition to understand the effect of using different ranges of pH on the performance of FFWM additives. First, 1% (10 gm) and 2% (20 gm) concentrations of FFWM were added to the reference fluid with pH = 9.3, then measurements have been conducted to investigate the effect of FFWM additive on the physical and chemical properties of the reference fluid. Secondly, caustic soda (NaOH) has been added to the initial reference mud to raise pH from 9.3 to 11.5, then 1% (10 gm) and 2% (20 gm) concentrations of FFWM have been introduced. Tables 3 and 4 show the effects of variation in the concentration of the FFWM on the properties of water-based mud with two conditions of pH [11].

2.4. Experimental investigation data of Palm Tree Leaves Powder (PTLP)

To distinguish the effect of presenting various concentrations of PTLP on the physical properties of the drilling fluid, the reference fluid (RF) was originally prepared, and it consisted of 700 cc of water, 1 gm of NaOH, and 45 gm of bentonite. Then, full-set measurements were conducted and recorded to the reference fluid in order to be compared to the effects of adding two concentrations of PTLP. Then, 1.5% (11 gm) and 3% (22 gm) concentrations of PTLP were added to the reference fluid. Afterword, full-set measurements have been conducted to investigate the effect of PTLP additives on the physical properties of the reference fluid.

1.5% (11 gm) and 3% (22 gm) concentrations of PTLP were first evaluated at the fresh conditions, then the same concentrations of PTLP were conducted at the aged conditions to distinguish the bacteria issues and the temperature impact, by leaving the samples of PTLP in the static conditions (lab room) for 24 hours, then placing them in the oven (dynamic conditions) under 55 °C (130 °F) for another 24 hours. For the fresh and aged environments, several properties of drilling fluid were measured, including but not limited to the rheological properties, the filtration characteristics, and the pH. For instance, the rheological properties including; the plastic viscosity, yield point, initial gel strength for 10 seconds, and the final gel strength for 10 minutes were conducted using the rotary viscometer. The filtration characteristics including the fluid loss in cc/7.5min and cc/30min as well as the filter cake thickness were measured using the standard low-temperature and low-pressure (LTLP) API Filter Press at 100 psi. Tables 5 and 6 show the data for 1.5% and 3% concentrations PTLP additives under the surface and sub-surface conditions, respectively [12].

2.5. Experimental investigation data of Grass Powder (GP)

LTLP filtration (75 °F and 100 psi) and HTHP filtration (250 °F and 500 psi) control experiments were conducted for each concentration to minutely evaluate the influence of 0.5% (3.5 g), 1% (7 g), and 1.5% (10.5 g) concentrations of GP and starch on drilling fluid properties. The LTLP filtration characteristics including; the cumulative filtrate loss for 7.5 and 30 minutes as well as the filter cake thickness were obtained for all mud samples using the standard API Filter Press at 100 psi. However, HTHP fluid filtration loss at 250 °F and 500 psi with standard API filter press was used to acquire the fluid loss only at 7.5 minutes and 30 minutes in addition to the filter cake, to evaluate the effectiveness of the GP as an environmentally friendly filtration control agent under surface and sub-surface conditions when comparing it to the reference fluid and starch. Also, other standard API drilling fluids testing equipment which are rheometer/viscometer, mud balance, pH meter and temperature, various chemical titrations, retort kit, and resistivity device have been utilized to assess the influence of GP on other drilling fluid properties when comparing it to the reference fluid and starch.

The readings that were obtained from the experimental work are presented in detail for the reference fluid and different concentrations of GP and starch. The findings included fluid samples mud weight (MW), plastic viscosity (PV), yield point (YP), initial and final gel strengths, filtration properties including fluid loss and filter cake thickness, and other physical and chemical properties. In addition, a summary of the experimental findings with the effect of concentration variation is shown in Table 7, which shows the experimental outcomes of the reference fluid (RF), the reference mud plus GP, and the reference mud plus starch [13].

2.6. Experimental investigation data of Green Olive Pits' Powder (GOPP)

In order to test two concentrations of Green Olive Pits' Powder (GOPP), a reference fluid (RF) must be made with basic components such as water (600 cc), caustic soda (NaOH) (0.1 gm), and bentonite (36 gm) to be as reference comparison point for fluid samples involving GOPP additives. The type of RF used was spud mud (freshwater bentonite). From here, two concentrations of GOPP were added to the mixture in order to change certain fluid properties and examine the effect of GOPP additives on the drilling mud characteristics.

Two test samples were made using the GOPP. The first one consisted of adding 0.75% (4.5 gm) of GOPP while the second one is composed of introducing 1.5% (9 gm) of GOPP. Each sample consisted of the same basic components mentioned above for RF. After mixing the powder, certain tests such as rheometer/viscometer, filter press, mud balance, and pH meter were conducted, to help to evaluate the effectiveness of the powder within each sample. The chemical and physical properties can be found in Table 8 [14].

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104945.

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