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Research on Air Flotation-Biochemistry-Ultra-Filtration Treatment Technology of Heavy Oil Sewage

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Abstract

At present, the quality of effluent water from the pretreatment process of ultra-filtration in BinYi station is poor, which lead to late block and effluent water is not up to A1 standard. Based on the analysis of the ultra-filtration membrane pollutants, a scale of 1 m^3/d field experiment was carried out in Binyi station. Air flotation- biochemistry –ultra-filtration process was used, biochemical degradation strains of COD (BW-1, BW-2, BW-3, WSW-4) and heavy oil degradation strains (3-2-1, 1-2-1) were inoculated. After treatment, the COD of ultra-filtration effluent decreased from 300-400 mg/L to 60-80mg/L, oil content decreased from 20-60 mg/L to about 1 mg/L, suspended solids reduced from 50-100 mg/L to under 1mg/L, the median diameter decreased from 6.4 μm to 0.8 μm, SRB reduced from 25 to 0 per milliliter, HCO^{3-} decreased from 500-600 mg/L to below 100 mg/L, the hardness decreased from 11-12 mmol/L to 10-11 mmol/L, NO^{3-} increased from 0 to 63 mg/L, SDI reduced to 4.8.

Key words: Heavy oil sewage; Biochemical; SDI

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INTRODUCTION

The sewage station capacity of Bin1 united station of Binnan oilfield is 1.4× 10^4 m^3/d to 1.7 × 10^4 m^3/d. Among them, there are seven fine processing station, the treatment capacity is about 2,000 m^3/d. The heavy oil sewage treatment is difficult[1] and the pretreatment of oil removal is not perfect, which lead to fine filtration effluent is not up to standard, suspended solid content is more than 2.5 mg/L, median suspended particle size is greater than 2μm. This condition can not meet low permeability oilfield A1 standard, at the same time, the stable operation process cycle is short, and fine filter should be replaced every 1 to 2 years. To solve the above problems, biological, chemical analysis of sewage and the composition analysis of ultra-filtration membrane pollution on Bin1 station were carried out; a high efficient degradation bacteria group was screened and build, the effective removal of sewage petroleum, organic pollutants and inorganic scale were realized, which fundamentally solve the impact on the subsequent fine filtration treatment facilities. Ultra-filtration water quality not only reached the A1 low permeability oilfield reinjection standard[1], but also can be treated with reverse osmosis directly, which provide a technical thought for the future of the recycling of sewage.

1. PRESENT SITUATION OF SEWAGE AND TREATMENT PROCESS

1.1 Bin1 and Water Quality Analysis

Bin1 station existing treatment processes include Oil-water separation, sewage modification, flocculation precipitation, sterilization, scale inhibition, corrosion inhibition, multiple medium filtering, fine filtration. The effluent of fine filtration is reinjected. The water quality analysis of effluent of the oil-water separation is shown in Table 1.

[1] Clastic Rock Oil Reservoir Water Injection Quality Recommended Indexes

Table 1
Analysis Results of Water After Oil-Water Separation

Items	Test value	Items	Test value
Temperature, ℃	48	Calcium, mg/L	356
pH	6.85	Strontium, mg/L	68
Oil, mg/L	56	Barium, mg/L	Not detected
Suspended solids, mg/L	62	Chlorine, mg/L	9,375
Total nitrogen, mg/L	23	Sulfate radical, mg/L	188
Total phosphorus, mg/L	1.7	Bicarbonate radical, mg/L	703
Sodium, mg/L	6362	Salinity, mg/L	17,177
Potassium, mg/L	11	COD, mg/L	360
Magnesium, mg/L	74	TOC, mg/L	104

Analysis of membrane pollutants is shown in Table 2:

Table 2
Analysis of Membrane Surface Pollutants

Organic pollutants	73.7%	Alkanes, aromatic hydrocarbons, colloid	53.4%
		asphaltene	15.3%
Inorganic pollutant	36.3%	Calcium carbonate	16.1%
		Quartz	1.2%
		Barium sulfate	2.8%
		Strontium sulfate	0.9%
		Others	15.3%

1.2 Screening of High Efficient Bacteria

According to the characteristic pollutants in Wastewater, high efficient bacteria were screened. Degrading bacteria of COD (BW-1, BW-2, BW-3, WSW-4) and heavy oil degrading bacteria (3-2-1, 1-2-1) were constructed. The BOD/COD value before and after inoculation was shown in Table 3.

Table 3
The BOD/COD Value Before and After Inoculation

	BOD	COD	BOD/COD
Before inoculation, mg/L	80	360	0.22
After inoculation, mg/L	150	360	0.42

1.3 The Test Process

Test procedures include air flotation-Standing settling-activated sludge—the second pond - immersion ultra-filtration, the retention period of each paragraphs is 6 h, 2 h, 6 h, 3 h, 1 h respectively, the total residence time control within 18 h.

Air Flotation Parameters: Air flotation pool effective volume: 0.8 m^3, Facility gas water ratio: 20:1.

Biochemical Parameters: Biochemical pool temperature: 35-40℃, Biochemical pool DO: 2-3 mg/L, Sludge concentration: 2 g/L, SV30: 20%-30%.

Ultra-filtration Parameters: external pressure type hollow fiber membrane, The filter aperture: 30nm, Feed water pressure: 0.03-0.05 MPa, Membrane flux is 20-40L/$m^2 \cdot h$[2].

2. RESULTS AND DISCUSSION

2.1 Experimental Start-Up

Biochemical system started up with a kind of cultivation and domestication method which inoculate condensed sludge and add up the obligate degradation bacteria group. Put concentrated activated sludge 100 kg into the biochemical pool, then add the indoor fermentation cultivated hybrid bacteria liquid 10 kg, include BW-1, BW-2, BW-3, WSW-4, 3-2-1, 1-2-1. Add Binyi sewage water (from the oil-water separator) to 0.8 m^3, and then open the Roots blower aeration, adjust the gas flow, make sure the biochemical pool water dissolved oxygen is about 2 mg/L. The first day, plus glucose 300 g. The second day, 240 g. The third day , 180 g, daily reduced 60 g, stop until the sixth day. The third day, began to inflow water slowly, the speed is 20 L/h, the fourth day speed is 40 L/h, increasing 20 L/h day after the fourth day, maintain stability when it keeps the speed of 140 L/h.

2.2 COD Removal Efficiency

Removal effect of COD is shown in Figure 1.

As can be seen from Figure 1, the treatment process of air flotation and sedi- mentation can remove 100mg/L of COD, after biochemical treatment, the COD can be reduced under 100mg/L. Ultra-filtration remove part of the colloid, so that COD further reduced.

2.3 Oil Removal Efficiency

Removal effect of oil is shown in Figure 2.

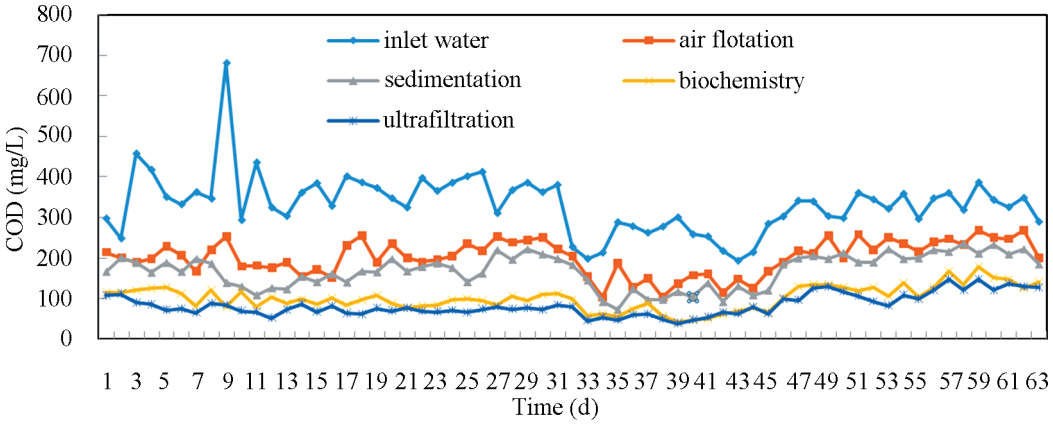

Figure 1
Removal Efficiency of COD

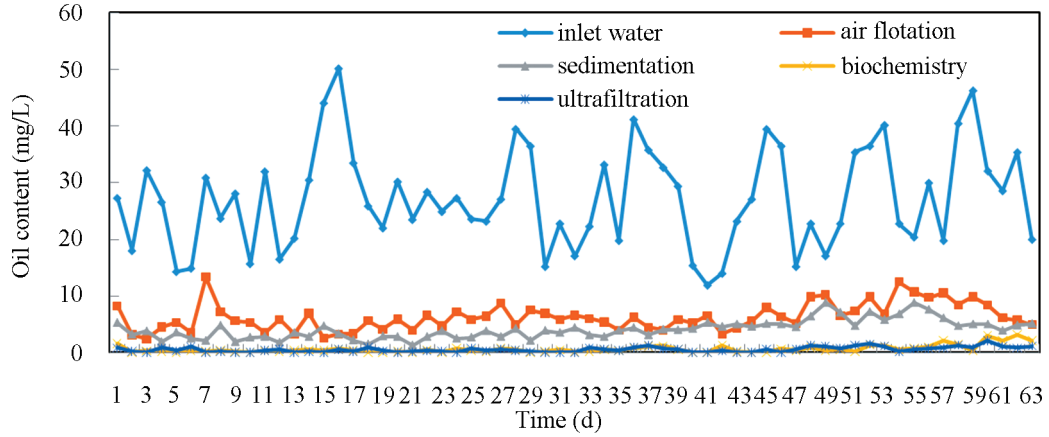

Figure 2
Removal Efficiency of Oil

Data in Figure 2 shows that the treatment process can decrease the concentration of oil to less than 1.5 mg/L. This is due to air flotation can remove most of the floating oil, biochemical treatment can remove the rest dissolved oil and emulsified oil. In biological treatment, oil and other organic components are adsorbed and then degraded by microbial oxidation. So, there is a concentration difference which allows the contaminants in wastewater be constantly adsorbed to the bio-film. Furthermore, the bacterial community structure is relatively stable after the stable operation of the system. As a result, the oil contaminants that may cause membranes fouling are decreased gradually.

2.4 Hardness Removal Efficiency

Removal effect of hardness is shown in Figure 3.

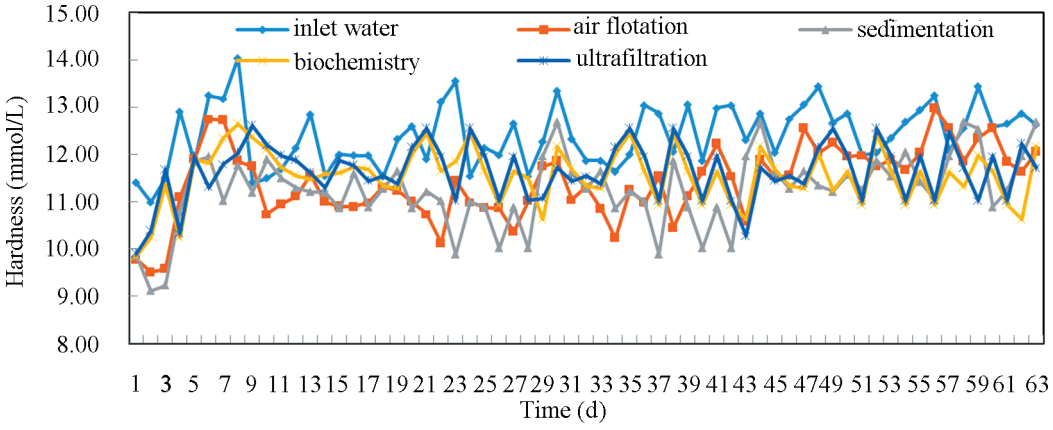

Figure 3
Removal Efficiency of Hardness

The figure above shows that the hardness was 10.5-14.0 mmol/L in the inlet, and was Slightly decreased in outlet after treatment.

2.5 Suspended Solid Removal Efficiency

Removal effect of suspended solid is shown in Figure 4.

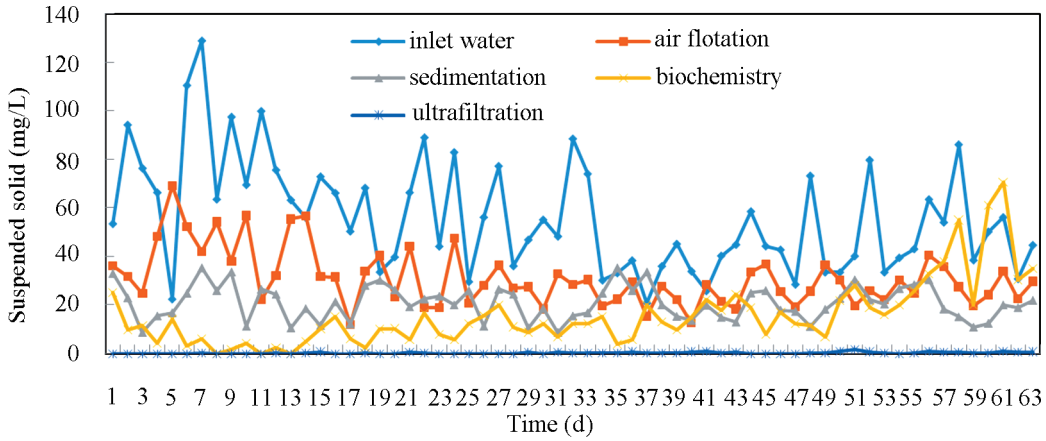

Figure 4
Removal Efficiency of Suspended Solid

The figure above shows that the suspended solid was 20-120 mg/L in the inlet, and was nearly 0 mg/L in outlet after treatment.

2.6 Change of SRB, Negative Bivalent Sulfur, Median Particle Size and SDI

The change of SRB, Negative Bivalent Sulfur, Median Particle size and SDI were shown in table 4. Air flotation can get rid of the negative bivalent sulfur and most of the SRB, the reason is the oxidation of oxygen in the air. Ultrafiltration can slash suspended solids and median particle size widely, make water SDI reduced to below 5.

Table 4
Change of SRB, Negative Bivalent Sulfur, Median Particle Size and SDI

	Inlet water	Air flotation	Biochemistry	Ultra-filtration
RB, mg/L	25	2.5	0	0
Negative bivalent sulfur, mg/L	12	0	0	0
Median diameter, μm	6.4	2.0	2.5	0.8
SDI_5	16.8	17.2	14.3	4.6

CONCLUSION

(a) As biochemical pretreatment, air flotation can make oil content be stable under 10 mg/L. This can reduce the burden of the process system, and recycle 70%-80% of the crude oil.

(b) After biochemical treatment, HCO_3^- and hardness are falling, especially HCO_3^-. It slowed or even completely eliminated sewage scaling problems, reduce the burden of ultra-filtration greatly and extend the backwashing cycle of ultra-filtration.

(c) The COD of ultra-filtration water keeps stable at 40-60 mg/L, which had a positive impact on the next step of sewage recycling use.

(d) Activated sludge and immersion ultra-filtration can intercept almost all colloid, microorganism, suspended solids in the water[3], the water can not only achieve low permeability oilfield reinjection standard A1, but can be used directly in reverse osmosis. It provides a technical idea for sewage recycling use.

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