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Microbiological Control and Successful Quality Maintenance of Reinjected Water In Onshore Operations, A Case Study

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ABSTRACT

The Effluent Treatment Plant of Kamalapuram (KMP) Karaikal, Cauvery Asset, generates 100 to 150 M^3 per day quantity of effluent which is reinjected for enhanced oil recovery. The plant is operated once in two or three days and sometimes more than this. During this time the treated effluent is stagnant in treated tanks available at KMP, Effluent Treatment Plant (ETP). The effluent in Kamlapuram ETP plant was being treated with 10 ppm of aldehyde & amine type bactericides alternately, however, in spite of the treatment, blackening of water was observed in the water storage tank.

Since KMP effluent contains higher concentration of iron and sulphate (Iron:30-50 ppm and Sulphate:250-470 ppm), it was suspected that, this may have led to growth of sulphate reducing bacteria and may be the reason for turning the water to blackish colour, which was not desirable. Also the design of the process has several ideal locations for bacteria to find niche and form colonies. The situation demanded detailed study, dose optimization of the amine and aldehyde type biocides used for treatment purpose at KMP, Karaikal.

Detailed study of samples from all the steps of the process revealed the actual microbial load and requirement of optimized biocide treatment of the system .High counts of SRB, General aerobic bacteria (GAB) were observed. Bactericide kill doses of the two types of biocides were ascertained against the different cultures (GAB & SRB) growing in these samples obtained from various phases of the process. The optimized doses were found to be higher than those being in practice. Implementation of the recommended doses of biocides in the plant evinced to bring the microbial problem under control and get the desired quality of injection water for enhanced oil production.

Keywords: Sulphate-reducing bacteria (SRB), General aerobic bacteria (GAB), Microbiologically induced corrosion (MIC), ETP (Effluent Treatment Plant)

INTRODUCTION

Extraction of oil and gas from underground reservoirs often is accompanied by water or brine, which is referred to as produced water. The bulk of produced water from land-based operations is re injected. Injection of these waters back into the petroleum reservoir serves three purposes: it produces additional petroleum through secondary recovery (water flooding), it uses a potential pollutant, and, in some areas, it controls land subsidence[1].

Cauvery Asset (of ONGC) covers an area of about 25000Sq.Km in the onshore and extends from Puducherry in the North to Ramnad in the South and Thiruvarur, Thanjaur in the West to Karaikal in the East. As of today asset is covered by 31 Fields. Various installations spread throughout Tamil Nadu are, Group Gathering Station (GGS 2), Gas Collection Station (GCS 3), Central Tank Farm (CTF 1), Early Production System (EPS 13) and ETP (2).

Adiyakamangalam (AKM GGS) and Kamalapuram (KMP EPS) are two major production installations of Cauvery Asset situated at a distance of 40-50 Km away from Karaikal Base Office. The average crude oil production at AKM GGS & KMP EPS is approximately 75 Metric Ton (MT) and 160 MT respectively and accordingly these installations are generating nearly 110 m^3 of effluent. In order to treat and dispose of this effluent a Combined ETP is commissioned and has been operational since June-2015.

AKM GGS

The crude oil produced from oil wells, is processed at AKM Group Gathering Station to separate associated gas, crude oil and water. The separated effluent water containing free oil, emulsified oil, dissolved and suspended solids is pre-treated before sending to Combined ETP at KMP.

KMP Combined ETP

Kamalapuram has a primary treatment facility for 250m^3 along with total treatment facility for 500m^3 effluent to take care of effluent generated at both Adiakamangalam and Kamalapuram.

The treatment scheme at Combined ETP-Kamalapuram, is carried out in the following sequence:

- Removal of Free oil & Sediments TPI (Tilted plate interceptor) separator is used for separation of free oil or suspended solids from oily water effluent.

- Flow Equalization

• After flow equalization, coagulation, flocculation and clarification is carried out.

• Chlorination Treatment with Sodium hypo chlorite (Chlorinating Agent) is done in order to prevent algae growth in treated disposal pipeline and to reduce biological oxygen demand (BOD). Dosing of sodium hypochlorite solution is done in the filter feed sump.

• Filtration Filtration is a polishing step, which arrests the particles that are too small to be removed by gravity separation. The process of filtration is comprised of mechanical straining, diffusion, adsorption and absorption. The effluent passes through a bed of granular filter media, which normally consists of different layers of gravels, anthracite, activated carbon and fine sand. The small suspended solids in the effluent are trapped in the filter and the clear water flows out from the bottom of the filter.

• Chemical conditioning The filtered water is made suitable for reinjection in abandoned wells by the addition of chemicals such as ammonium bisulphite, sodium hexa-meta-phosphate and biocides to prevent corrosion, scaling and biological growth.
• Disposal The effluent is to be treated to meet discharge standards for reinjection.

Aldehyde & amine (10 ppm each) type bactericides, were alternatively used. Quantity of effluent generated ranged from 100 to 150 M^3 per day, therefore plant was operated once in two or three days and sometimes more often. In the meantime this treated effluent was stagnant in tanks available at KMP ETP. While injecting this stored water it was observed that treated water turned blackish.

Since KMP effluent contains higher concentration of iron and sulphate (Iron:30-50 ppm and Sulphate:250-470 ppm) this may lead to growth of SRB and this may be the reason for turning water to blackish which is not desirable.

Estimation of bacterial load & dose optimization of the Amine and Aldehyde type biocides used for treatment purpose at Karaikal was essential.

As Karaikal unit does not have facilities, the job was to be carried out at RGL, Mumbai which is approximately 1500 km from Karaikal. It was planned to enumerate GAB and SRB to find out bacterial load in the system. Dose optimization of the amine and aldehyde type biocides used for treatment purpose at Karaikal was carried out. Bactericide kill dose of the two type of biocides were ascertained against the different cultures (GAB & SRB) growing in these samples.

EXPERIMENTAL

METHODOLOGY APPROACHED

- Samples from different sampling locations of Kamalapuram ETP plant were collected and inoculated as per standard practices for enrichment/enumeration and detection of GAB, SRB by the Chemistry Surface Team, in culture media vials provided by Microbiology Lab. RGL, Panvel. Serial dilutions of the samples were carried out in broth media vials.

- Inoculated vials were sent to RGL, Panvel. Vials were kept in the incubator at 35^{o}C.

- Observations for GAB were recorded on receiving and for SRB, vials were further incubated up to 28 days of incubation and observed.

- GAB, SRB cultures developed from each of the sample were sub cultured and used for biocide evaluation test with aldehyde and amine type biocide samples being used for the treatment of effluent water (which is to be injected) at Kamlapuram ETP.

- Aldehyde and amine type biocides samples were tested at various doses by time kill test method. Biocide exposure time was 4 hours in all the tests.

- Results of the dose optimization experiments were recorded after 4 days & 28 days of incubation for GAB and SRB respectively.

RESULTS AND OBSERVATIONS

Test results

Table 1: Enumeration of GAB and SRB from samples

Test ⇒ Sample ⇓	GAB Counts (No. per ml)	SRB Counts (No. per ml)
TPI Inlet	10^4	10^3
TPI Outlet	10^4	10^2
Raw Water	10^7	10^7
Treated Effluent	10^4	10^2

Table 2: Time kill test with Biocide Aldehyde on GAB sub-cultures developed from Kamplapuram ETP.

Biocide Aldehyde	100 ppm	200 ppm	300ppm
TPI Inlet	-- --	-- --	-- --
TPI Outlet	-- --	-- --	-- --
Raw Water	++++	++++	-- --
Treated Effluent	-- --	-- --	-- --

Table 3: Time kill test with Biocide Amine on GAB sub-cultures developed from Kamplapuram ETP.

Biocide Amine	100 ppm	200 ppm	300ppm
TPI Inlet	++ ++	-- --	-- --
TPI Outlet	-- --	-- --	-- --
Raw Water	-- --	-- --	-- --
Treated Effluent	-- --	-- --	-- --

Table 4: Time kill test with Biocide Aldehyde on SRB sub-cultures developed from Kamplapuram ETP

Biocide Aldehyde	100 ppm	200 ppm	300ppm
TPI Inlet	-- --	-- --	-- --
TPI Outlet	-- --	-- --	-- --
Raw Water	-- --	-- --	-- --
Treated Effluent	-- --	-- --	-- --

Table 5: Time kill test with Biocide Amine on SRB sub-cultures developed from Kamplapuram ETP

Biocide Amine	100 ppm	200 ppm	300ppm
TPI Inlet	++ ++	++ ++	-- --
TPI Outlet	-- --	-- --	-- --
Raw Water	++ ++	++ ++	-- --
Treated Effluent	++ ++	-- --	-- --

Key: - - - - No Growth
++ ++ Growth

OBSERVATIONS AND DISSCUSSION

1. GAB counts for TPI Inlet,Outlet and Treated Effluent were 10^4 per ml while for Raw water it was 10^7 per ml. SRB counts for TPI Outlet and Treated Effluent was 10^2 per ml , 10^3 per ml for TPI Inlet and 10^7 per ml for Raw water.(Table-1).

2. Biocide aldehyde tested against GAB sub-cultures showed that it was effective at 100 ppm in case of TPI Inlet,Outlet and Treated Effluent while for raw water the effective dose was 300 ppm. (Table-2).

3. Biocide amine tested against GAB sub-cultures showed that it was effective at 100 ppm in case of TPI Outlet , raw water and Treated Effluent, while for TPI Inlet the effective dose was 200 ppm. (Table-3).

4. Biocide aldehyde tested against SRB sub-cultures showed that it was effective at 100 ppm for all the samples. (Table-4).

5. Biocide amine tested against SRB sub-cultures showed effectiveness at 100 ppm in case of TPI Outlet while for Treated Effluent the effective dose was at 200 ppm and forTPI Inlet and raw water the effective dose was 300 ppm. (Table-5).

CONCLUSIONS

- Water samples of TPI Inlet, TPI Outlet, Raw Water and Treated Effluent from Kamlapuram ETP showed presence of bacteria in high numbers.
- The raw water sample in particular was detected with highest bacterial numbers possibly because it received water from different sources and chemicals.
- Samples from various sources showed differences in sensitivities towards the two biocides.
- Biocide aldehyde was effective at 100 ppm dose for GAB cultures developed from TPI inlet, outlet and treated effluent, however it showed effectiveness only at 300 ppm for raw water culture.
- Biocide amine type was effective at 100 ppm dose for GAB cultures developed from TPI outlet, raw water, and treated effluent but was effective at higher dose of 200 ppm for TPI inlet.
- For SRB cultures developed from all the samples biocide aldehyde type was effective at 100 ppm. However, biocide amine, was effective at a higher dose of 300 ppm against TPI inlet and raw water SRB cultures and 100 ppm for TPI outlet and treated effluent SRB cultures.

RECOMMENDATION/SUGGESTION

- After conducting the detailed studies, it was recommended to use aldehyde type biocide at 100 ppm for four hours at TPI inlet, TPI outlet and treated effluent.
- For treatment of raw water, 300 ppm of aldehyde type biocide was desired, as has been observed during studies.
- Recommended dose for the treatment of TPI inlet and raw water with amine type biocide was 300 ppm and for treated effluent 200 ppm. TPI outlet to be treated at 100ppm.
- It was recommended to monitor GAB and SRB counts and dose the biocides accordingly, as it is expected to control bacteria after initial treatment with above suggested doses.

  After implementing the recommended doses the plant is being operated successfully, without microbial problems and the team received appreciation letter.

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REFERENCE

1) Produced oilfield water, PetroWiki published by SPE (https:/petrowiki.org)

Annexure I