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The main sources of wastewater and sea contamination in the South Pars natural gas processing plants: Prevention and recovery

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ABSTRACT

This study was carried out during 2012–2013 at South Pars Gas processing plants, which is located in Assaluyeh city, southern part of Iran. The project involves the sources of wastewater pollutants in oily wastewater process and collects samples for analysis. The parameters that affect the environmental pollution are BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), pH, TSS (Total Suspended Solid), Mono Ethylene Glycol (MEG) and hydrocarbon which are determined in oily wastewater. The goal of this research is to show source reduction through process modification is a viable technique to minimize process waste. To accomplish this objective some operational and technical suggestions were presented to improve the current process at South Pars Gas processing plant. These recommendations would play a major role in the advancement and optimization of the wastewater treatment process. For wastewater disposal to surface water, Iranian National Standard limitations are applied. Our study demonstrates that COD concentration of effluent streams of API and Induced Gas Floatators (IGF) (oily water treatment sections) is above the standard level and tends to fluctuate. Hence, alternative modification and treatment processes such as biological and advanced oxidation process have been applied for increasing recovery and improving COD removal from wastewater.

1. Introduction

Nowadays, environmental pollution has already reached to a certain scale that it threatens and endangers the health of human beings and survival of other living things. For the same reason, most countries especially industrial countries have taken certain fundamental measures for the prevention of environment pollution (Sadatipour et al., 2004). Good quality water is often required in order to comply with environmental standards and regulations. Additionally, in areas of limited water resources, water economics may dictate the possible reuse of wastewater effluent. Such requirements and considerations necessitate the efficient treatment of the wastewater for the removal of hazardous contaminants (Malik et al., 2007; Tellez et al., 2002).

Natural gas industry is a major source of energy and revenue for many countries today (Ekins et al., 2007). Despite its significance, gas refinery effluents facility especially hydrocarbon processing process are produced with large volumes of waste, with wastewater accounting for more than 80% of liquid waste. Produced water has a complex composition, but its constituents can be broadly classified into organic and inorganic compounds, including dissolved and dispersed oils, heavy metals, treating chemicals, formation solids, salts, dissolved gases, scale products, microorganisms and dissolved oxygen (Diyauddeen et al., 2011; Ahmadun et al., 2009).

The discharge of these wastewaters into the environment adversely affects the ecosystem. A consequence of the generation of these toxic effluents is devastating and detrimental (Diyauddeen et al., 2011). The handling and treatment of refinery wastewater streams vary from one facility to another depending on the specific characteristics of wastewater generated, as well as composition of condensate and pretreatment processes applied (Benyahia et al., 2006). While conventional refinery wastewater treatment technology is mainly focused on the removal of oil, organics, and suspended solids prior to discharge; end-of-pipe treatment became a necessity for many refineries because of stringent discharge requirements for the effluent (Wong and Hung, 2006). Currently, gas operators treat produced water via one or more of the following options:

† Avoid production of water: water fractures are blocked by polymer gel or downhole water separators, but this option is not always possible.

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† Discharge to the environment: produced water may be discharged to the environment as long as it meets onshore and offshore discharge regulations.

† Apply in beneficial uses: produced water may be consumed for irrigation, wildlife consumption and habitat, industrial water and even drinking water. However, beneficial uses of produced water may involve significant treatment (Reynolds and Kiker, 2003; Igunnu and Chen, 2013).

The treatment of refinery effluents has undergone changes in technological approaches both at the pre-treatment and at the advanced stages. The physical separation of condensate, colloids and suspended solids remains the preferred pre-treatment method due to its efficiency in separating heavier fractions of the waste. Many technologies are used for the advanced treatment stage of the primary effluent; however, each possesses several drawbacks. Some recalcitrant and persistent compounds are not adequately eliminated by the biological method, which is the traditional approach (Ahmadun et al., 2009).

Various studies have been reported in literature on the treatment and disposal or reuse of wastewater effluent from petroleum refineries facilities (Wong and Gerhardt, 2002). Many researchers have shown biological treatment of petroleum refinery or some its compounds wastewater to be effective and efficient methods (Jou and Huang, 2003; Sami Sarfaraz, 2004; Fang et al., 2006; Yoong and Lant, 2001; Ma and Love, 2001).

Improved water management in a refinery can potentially reduce the volume and cost of raw water used in refinery operations. Furthermore, improved water management may result in reductions in wastewater flow or contaminant load or both. Lower flow and contaminant load may result in lower wastewater treatment operating and maintenance costs. Optimized water management may also reduce the mass of contaminants in the treated effluent, so improving the quality of the wastewater discharge and ultimately the environmental impact of a refinery's discharge. These practices are a collection of operational equipment and procedural actions related to water management in a refinery (Elias-Samlalsingh and Agard, 2003; Rase, Barrow, 1977; Gasim et al., 2012). Since each refinery is uniquely configured, some of these practices may or may not be applicable based on the complexity of the refining operations, type of wastewater treatment operations available at a particular site, availability of raw water sources, discharge configuration and type of receiving water body. This manual will enable a refiner to compare their operations with typical industry practices and develop a plan for optimizing water management in the refinery. The purpose of this study is to identify the various sources of wastewater in the South Pars natural gas processing plants in Asalooyeh, Iran from both quantitative and qualitative viewpoint. Moreover, some operational and process modifications made in the plants were mentioned and relevant effectiveness was discussed.

2. Evaluation of different types of wastewater

According to design and actual data, there are two different types of wastewater in South Pars Gas Complex refineries.

2.1. Sanitary wastewater

Sources of sanitary wastewater are lavatories, bathrooms, washstands and kitchen.

2.2. Oily wastewater

This type of wastewater consists of three different wastewaters:

1 Oily wastewater
2 Accidentally Oily Contaminated (AOC) water, like rainfall
3 Various wastewaters from sulfur recovery, sour water, steam generation and chemical storage process.

2.2.1. Oily wastewater treatment package

The oily wastewater treatment section removes the free oil from the wastewater but has limited removal efficiency to the dissolved and the dispersed oil droplets. This process is a combination of two parts:

1 Oil removal from oily water.
2 Collecting the separated oil and its recovery.

As it can be seen in Fig. 1, at first oily water and neutralized spent caustic are collected in Oily Water Inlet Sump. In the case of low feed flow, oily wastewater could be fed to Inlet Sump from Catch Pit. Catch pit is a part of Storm Basin and is connected to Adjacent Basin via overflow path. At very high and non-controllable flow, extra flow is transferred through this overflow to the Adjacent Basin and then could be transferred to the sea by three pumps in emergency cases.

Oily water is pumped from Oily Water Inlet Sump to API separators, and is mixed with demulsifier solution. Demulsifier is added in proportion to the flow to aid oil separation. Suspended oil is separated from wastewater stream, and is skimmed by skimmers. The effluent is injected from the API to Induced Gas Floatators (IGF). The treated water from the flotation process is discharged by gravity to the Observation Basin, and finally is sent to Outfall Basin and then sea water. Feed sources of Observation Basin are; IGF, Condensate Chamber extra flow, boiler blow down from sulfur recovery and steam generation, stripped water from sour water process, excess chemical wastewater from chemical sewer and steam condensate from chemical storage process.

3. The sources of wastewater releases

The potential releases into water in South Pars Gas processing plants are from carryover and leakages of Amine, Mono Ethylene Glycol (MEG) and hydrocarbon compounds which arise from inadequate separation performance. The main process sources of wastewater in South Pars Gas processing plants are:

3.1. Sour water stripping

Sour water stripping is an important part of gas processing plants strategy for preventing or minimizing releases to water. Hydrogen sulfide, MEG and hydrocarbon which emanate from the MEG regeneration, Burn Pit and Condensate Stabilization process are the principal sources of sour water. Other source includes Amine from Inlet Gas Dryer Separator of dehydration process. Sour water streams are collected in enclosed systems and fed to steam strippers to remove only volatile noxious substances. Sour water is collected from the various sources in a feed drum with separating facilities for hydrocarbons and sour gas which Sour water is pumped to the top of the Stripper packed tower, and hydrocarbons are passed to Off-Spec Condensate Tank or Burn Pit. Steam is injected into the bottom of the tower fitted with a steam heated reboiler. Overheads are condensed with the condensates being returned as reflux to the column, and the gas typically consists of hydrogen sulfide and mercaptan. Fig. 2 shows the concentration of MEG in the effluent of sour water which routed to the Condensate Chamber or Observation Basin in the wastewater treatment process. Results demonstrate that the effluent from sour water process carries an average of 480 ppm MEG, which is considerably higher than the