Int. J. Econ. Environ. Geol. Vol. 9(2)86-88, 2018
Journal home page: www.econ-environ-geol.org

Open Access
ISSN: 2223-957X

Determination of Oil and Grease in Produced Water and their Effects on Surrounding Soils

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Received: *26 March, 2018* ***Accepted:*** *26 June, 2018*

Abstract: This study was conducted to determine the concentrations of oil and grease in produced water from Sadqal oil and gas field in Fateh Jang, Punjab, Pakistan and their impact on surrounding soil. Produced water samples were collected from various locations including inlet of pond A, pond A, inlet of pond B, pond B, outlet of pond B and external stream. Concentration of oil and grease from various locations showed that all values were higher than the permissible limit of Pakistan Environmental Protection Agency (Pak-EPA). Soil samples were collected from the same location points of the produced water. In soil samples oil and grease were found in high amounts due to continuous discharge of produced water in that area. Therefore, produced water should be treated properly before being released into the surrounding environment and Pak-EPA should have regular monitoring programs.

Keywords: Produced water, soil, oil and grease, Pak-EPA.

Introduction

Petroleum industry got its great significance due to manufacturing of various products and it was well known around the world for a large percentage of energy consumption. Oil production has significant impacts on environment like global warming, poor water quality, soil contamination, and surface and ground water contamination which leads to disturbance of flora, fauna and the ecosystem (Jaferinejad, 2017). Produced water can be defined as water that is brought up to the surface from hydrocarbon bearing strata containing various contaminants (Veil et al., 2004). Produced water is mainly composed of organic and inorganic compounds, total dissolved and suspended solids, heavy metals, and some naturally occurring radioactive elements (Dorea et al., 2007). Oil and grease constituents found in produced water are mainly composed of various hydrocarbons. These hydrocarbons are persistent in nature and percolate in nearby areas affecting the quality and productivity of soil. Hydrocarbons, when they enter the soil, they affect soil enzymatic activity and carbon distribution of microbial biomass greatly (Alrumman et al., 2015). Oil and grease in waste water cause accumulation of oil and grease compounds in soil and also resist flow of water deep into the soil, thus affecting land fertility, (Travis et al., 2008). Soil irrigated with oil and grease contaminated water also causes contamination of ground water source (Mahmoud et al., 2010). Lower weight hydrocarbons in oil and grease leak into the soil rapidly and contaminate ground water quality and affect functioning of soil and plant growth. Greater the volatility and solubility of hydrocarbons, greater will be the movement of compound into the soil (Welch et al., 1999). Thus, to study concentration of oil and grease in produced water and their distribution on soil, these water and soil samples were collected from Sadqal oil and gas fields in Fateh Jang, Punjab, Pakistan. Produced water and soil samples were collected according to framed hypothesis from study area. It lies between latitude 33°35'29"N and longitude 72°38'55"E with different types of land use. The Oil and Gas Development Company Limited (OGDCL) has started exploration and production activities in Sadqal area in 1992. This oil field expanded in an area of approximately 100 canals. Total oil production in this field is 70 barrel per day while total produced water production is 300 barrel/day. Waste water is released one kilometer away from the plant into the ponds located near residential area. Moreover, excess water over flows from the ponds and makes its way into a stream. The excessive waste water seepages from the ponds thereby contaminate the nearby soil up to distance of < 1.5 km (Khan et al., 2015).

Materials and Methods

Sample Collection

Produced water and soil samples were collected from selected points of study area. Produced water was discharged at a distance of about 1.5 km from oil and gas fields. There were two large ponds named as pond A and pond B. Six points were selected for collection of produced water while five points were selected for soil analysis. Six selected points for collection of produced water were named as inlet, pond A, pond B, inlet of pond B, outlet of pond B and external stream. Soil samples were collected from points which were near inlet, pond A, pond B, between pond A and B and external stream (fig. 1).

Sample Analysis

For extraction of oil and grease, n-hexane was used. A sample of about 100 ml was taken in a separating funnel and 20 ml n-hexane was added to it. It was mixed vigorously and allowed to settle to let the aqueous and organic phase separate. Lower layer was removed in separate beakers and the organic layer was collected in a separate beaker. This procedure was repeated three

times for the aqueous phase to completely extract oil and grease. A small amount of anhydrous sodium sulfate was added for absorption of water contents. After this, n-hexane could evaporate, oil and grease concentration was determined by pre-and post-weight of container (US-EPA method 1664). For soil sample analysis, similar procedure was followed in the preparation of aqueous solution of soil sample. For this 1.0 g soil was taken in a beaker, 100 ml water was added in it and further 20 ml n-hexane was used to extract oil and grease by following the above procedure.

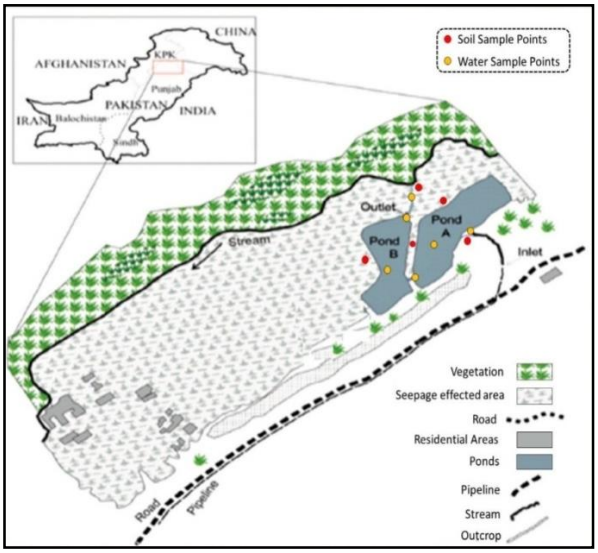

Fig. 1 Sample collection points (Khan et al., 2015)

Results and Discussion

Overall concentration of oil and grease was also determined in produced water and soil sample, taken from outside oil and gas field. Results in Table 1 showed that oil and grease concentration was found significantly higher in produced water and soil samples. Highest concentration of oil and grease in produced water was 199 mg/l at inlet of pond A, while least concentration of 120 mg/l was present at external stream. In pond A concentration of oil and grease was slightly reduced to 170 mg/l but when produced water entered pond B at its inlet, concentration of oil and grease was 163 mg/l. Similarly, in pond B, oil and grease had concentration of 160mg/l which continue to be reduced at the outlet of pond B i.e. 150 mg/l. Results of produced water samples were compared with Pak-EPA limits i.e. 10mg/l for oil and grease concentration in produced water. As shown in Figure 2, at all points, concentration of oil and grease was found to be higher than permissible limits. This produced water has significant impacts on human health as some of these pollutants evaporate and some of them percolate into ground water. Thus, health risks associated with such contaminants include heart defects, asthma attack, low birth weight, preterm birth and early deaths (Epstein, 2017).

Contrary to this, concentration of oil and grease was found to be far more than water in soil. Soil samples had more concentration of oil and grease than water at point 1 which was very close to inlet of pond A, while least concentration was 100mg/l in soil taken from point 6, which was external stream. At point 1 of soil sample collection, concentration of oil and grease was 250 mg/l, while soil collected from the area near pond A had concentration of 230 mg/l. Likewise, concentration reduced to 220 mg/l in soil collected from nearby pond B. Soil samples collected from the soil between pond A and B gave concentration of oil and greas as 215 mg/l (Fig 3).

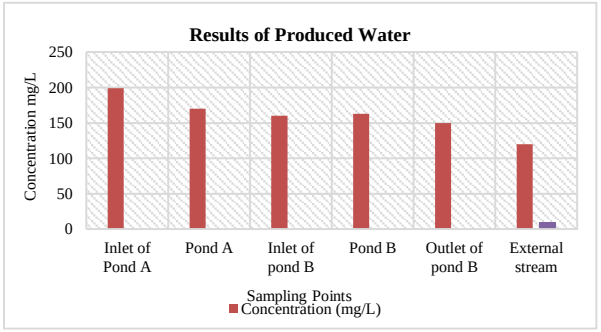

Fig. 2 Oil and grease concentration in produced water at various points.

Results clearly showed that at all points of produced water samples, oil and grease concentration was higher than above permissible limit of 10 mg/l defined by Pak-EPA. Concentration of oil and grease reduces as produced water flows from inlet of pond A to external stream (Table 1).

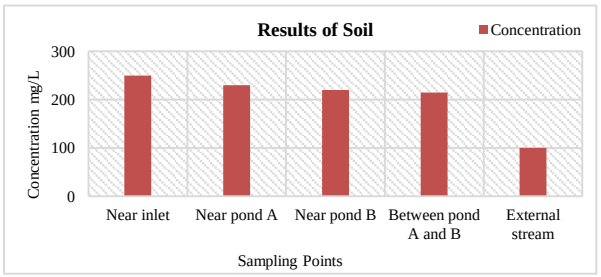

Fig. 3 Concentration of oil and grease in soil.

In soil samples, concentration of oil and grease was even more than the concentration in produced water. Main reason behind this fluctuation is continuous percolation of produced water in nearby soil, as soil samples were collected from zero-meter distance. Due to large amount of salt content in surrounding soil of this area (Khan et al., 2015), oil and grease contents continue to accumulate in soil with higher concentration. As solubility of organic compounds reduces with increase in salt content, unless higher temperature would be provided (Wongkaew et al., 2017). Continuous large amount of discharge of produced water not only affects quality of soil but also affects ground water quality and reduces the quality of nearby vegetation as well (Silva et al., 2017). Oil and grease concentration, if it continues to accumulate for longer period of time i.e. more than seven years, it causes accumulation of about 150mg/kg concentration up to 20 cm topsoil (Travis et al., 2008).

This clearly showed the reason behind large amount of accumulation of oil and grease in this soil, as it had been a long time that this area was used for the discharge of produced water from oil and gas field.

Conclusion

From all of the above discussion, it can be concluded that produced water has significant impacts on surrounding soil. Overall concentration of produced water was compared with Pak-EPA limit which is 10 mg/l oil and grease concentration in produced water. Results showed that highest concentration was 199 mg/l at inlet point, while this concentration was reduced to 120 mg/l when water entered into the external stream. Soil samples were also collected from nearby area to study the impact of produced water on soil. In soil, oil and grease concentration was found significantly higher, i.e. maximum concentration was found to be 250mg/l near inlet of pond A. Minimum concentration in soil was found in soil collected near external stream, which was 100 mg/l. It clearly shows that higher concentration of oil and grease has adverse impacts on nearby soil as well. Therefore, it is recommended that produced water should be treated properly before being released into the surrounding environment and Pak-EPA should have regular monitoring programs to control them.

Acknowledgement

Authors acknowledge the financial support provided by the Higher Education Commission, Islamabad, Pakistan.

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