Prevention of Sea-Water Pollution by Oily-Water Treatment

Ayoub Karimi Jashni[1], Solmaz Saadat[2]
Department of Civil Engineering, Shiraz University, Shiraz, Iran
Email address: ajashni@yahoo.ca Tel: 0917-3007901

ABSTRACT

Oil spills at sea are a major problem to the environment as they severely damage the surrounding ecosystems. Since crude oil is lighter than water, it floats on the sea surface. The initial treatment of an oil spill at sea includes mechanically skimming the water's surface, a mixture of floating oil, emulsified oil, tar balls, etc. will be taken onto the recovery barge and delivered for treatment and reclamation. A lab scale experimental research was conducted to investigate the effectiveness of different oily-water treatment technologies. This research investigated the effectiveness of Gravity Oil/Water Separation, Coagulation/Flocculation/Sedimentation, and Sand Filtration technologies. Effect of different parameters such as hydraulic residence time, type of coagulant, and coagulant dose were studied. It was concluded that more than 95% of oily compounds can be separated from oily-water waste which is an excellent step in preventing sea-water pollution.

INTRODUCTION

Oily-water waste are also produced from many industries, including: oil spills at sea, oil refining, collection points for disposable waste oils, petrochemical plants, crude oil storage, process operations, and tank cleaning services. The heavier hydrocarbon fractions of oily-water waste accumulate as bottom muck to kill plant and bottom dwelling animal life when released to surface waters. Dissolved or emulsified fractions act as toxic agents depleting the oxygen content of waterbodies. Floating fractions create fire hazards, and coat banks and boat hulls. They also contaminate the water, interfering with fishing and recreation.

The Persian Gulf represents a highly stressful environment due to a combination of both prevailing natural conditions and development pressures along its coastline. The Persian Gulf region has approximately two-thirds of the world's proven oil reserves and the eight riparian states (Iran, Iraq, Kuwait, Bahrain, Qatar, Sauidi Arabia, UAE and Oman) currently accounts for approximately one-fourth of the world's oil production. Problem associated with oil pollution and non-living resources appear to be of greater significance in Persian Gulf compared with other regions. This region has undergone considerable development, and consequently urbanization, industrialization, port areas and refineries have become major source of pollution to the marine environment. Also, a combination of tanker traffic and either accidental or intentional spills have prevailed. The spills that took place during the 1991 Gulf war is one of the major events happened in the Persian Gulf. In 1994, two tankers collided spilling 16,000 tonnes of Iranian

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[1] Assistant professor, Dept. of Civil Engineering, School of Engineering, Shiraz University, Shiraz, Iran.
[2] Ms. Student of Environmental Engineering, Shiraz University, Shiraz, Iran

crude oil into Gulf of Oman. Oil spills at sea like abovementioned ones need to be contained and managed to reduce the environmental effects.

The initial treatment of an oil spill at sea includes mechanically skimming the water's surface, a mixture of floating oil, emulsified oil, tar balls, etc. will be taken onto the recovery barge and delivered for treatment and reclamation. Employing appropriate oily-water treatment systems will augment the reclamation of saleable oil while preventing water pollution. Applying the correct technology to separate the oil from water is an important step in preventing sea-water pollution. Therefore, a research was conducted to investigate the effectiveness of different technologies for oily-water waste treatment. This lab scale experimental research investigated the effectiveness of the Gravity Oil/Water Separation, Coagulation/Flocculation/Sedimentation, Sand Filtration, and Activated Carbon Adsorption technologies.

LABORATORY METHODS

Preparation of oily-waste. Tap water was weighed into a clean glass blender container. Next, different mass of the oil (Behran engine oil) to be tested was added to the water, and the mixture was blended in the blender at high speed for 15 second. Therefore oily-water wastes with different oil content (different COD content) were obtained.

Reactor Configuration: The unite process (reactors) that were used in this research are shown in Fig. 1. The unite processes that were used were Gravity Oil/Water Separation, Coagulation/Flocculation/Sedimentation, and Sand Filtration. The dimensions of gravity oil/water separator was 30cm*23cm*16cm with a total volume of 10 L. The coagulation and flocculation reactors were cylinders with 9.5 cm diameter and 11 cm height. Sedimentation reactor was a cub with dimensions of 25cm*20.5cm*18cm with a volume of 7 L. Sand filtration reactor was a cub with surface are of 20 cm^2 and 20 cm height.

Measured water quality parameters: In order to calculate the effectiveness of each treatment unit, the quality of influent to each reactor and effluent from each reactor were measured. The water quality parameters chemical oxygen demand (COD), Turbidity, and oil content were measured. Using the measure water quality parameters the efficiency of each process unit were calculated. All these parameter were measure using the recommended procedures by Standard Methods (1981).

Coagulants: Four coagulants (Poly Aluminium Choloride (PAC), Aluminium sulphate, Ferrice sulphate and ferrous sulphate were used in this research. The choice of these coagulants was based on previous research by other researchers (Zhang et al., 2005, Rossini et al., 1999).

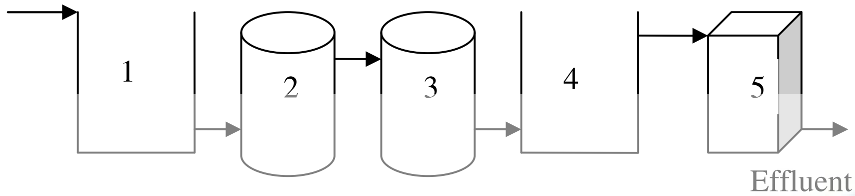

Fig. 1: Unit Processes Flow chart.

RESULTS:

1- Gravity Oil/Water Separation

Gravity separation is used to remove oil and grease and related pollutants from oil/water mixtures. Gravity separation is only effective for the bulk removal of free oil and grease. It is not effective in the removal of emulsified or soluble oils. During gravity oil/water separation, the wastewater is held under quiescent conditions long enough to allow the oil droplets, which have a lower specific gravity than water, to rise and form a layer on the surface. Large droplets rise more readily than smaller droplets. Once the oil has risen to the surface of the wastewater, it must be removed. This is done mechanically via skimmers, baffles, plates, slotted pipes or dip tubes. When storage tanks serve as gravity separators, the oil may be decanted off the surface or, alternately, the separated water may be drawn off the bottom. The resulting water may contain emulsified and dissolved oil which need further treatment to reach the required effluent standards.

In this research three oil/water mixtures with different initial CODs (5440 mg/l, 3480 mg/l, 2522 mg/l) were used. The oil/water mixture was poured into a gravity oil/water reactor (storage container). During gravity oil/water separation, the wastewater was held under quiescent conditions. At different time intervals, samples were taken and were analyzed for COD. The percentage of COD removal versus residence time in the gravity oil/water separator is shown in Fig. 2. This figure shows that the removal rate of COD (oil content) is very rapid at lower residence time and its removal after 100 min is not significant. Fig. 2 also shows that 40% to 60% of the oil can be separated from water by using a gravity oil/water separator and the remaining oil must be removed by using other technologies.

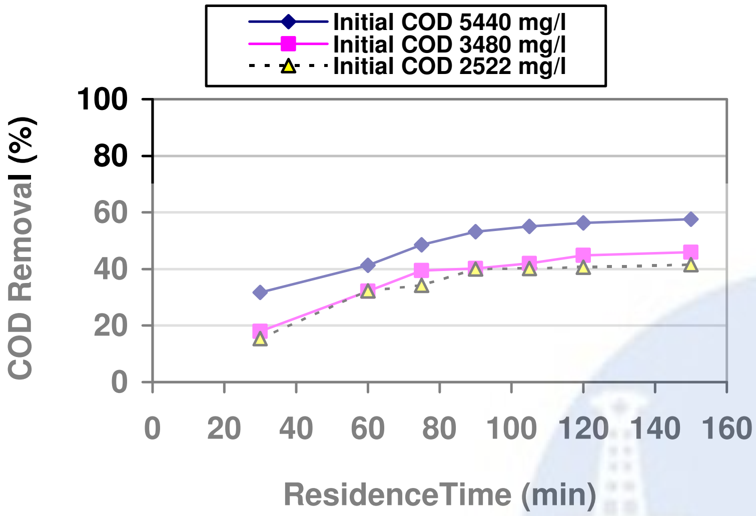

Fig 2: COD removal versus residence time in the gravity oil/water separator.

2- Coagulation/Flocculation/Sedimentation

Coagulation and Flocculation is the stirring or agitation of chemically-treated polluted water to enhance the separation of pollutants from water. In this research flocculation enhanced oil/water separation by joining emulsified oil and increasing oil particle size. Flocculation generally precedes sedimentation and filtration processes and usually consists of a rapid mix tank or in-line mixer, and a flocculation tank. The oil/water waste was initially mixed while a coagulant was added. A rapid mix (110 rpm) tank was used for detention time of 1 minute. After mixing, the coagulated oil/water waste flowed to a flocculation basin where slow mixing (20 rpm) of the waste occurred for 15 minutes. A mechanical paddle mixer was used to provide the necessary mixing. The coagulated oil/water waste flowed to a sedimentation basin where the coagulated particles (oil+coagulants) were separated from water either by flotation to the surface or sedimentation to the bottom.

The oil removal expressed as COD removal versus coagulant dose for different coagulants is shown in Fig. 3. This figure shows that by using 50 ppm of PAC or 120 ppm of aluminium sulphate about 9o% of the COD was removed. Using higher doses of these coagulants did not improve the COD removal. Fig. 3 also shows that coagulants ferrice sulphate and ferrous sulphate had lower efficiency comparing to PAC and aluminium sulphate. Higher dose (250 ppm) of ferrice sulphate and ferrous sulphate was able to increase the COD removal to 80%.

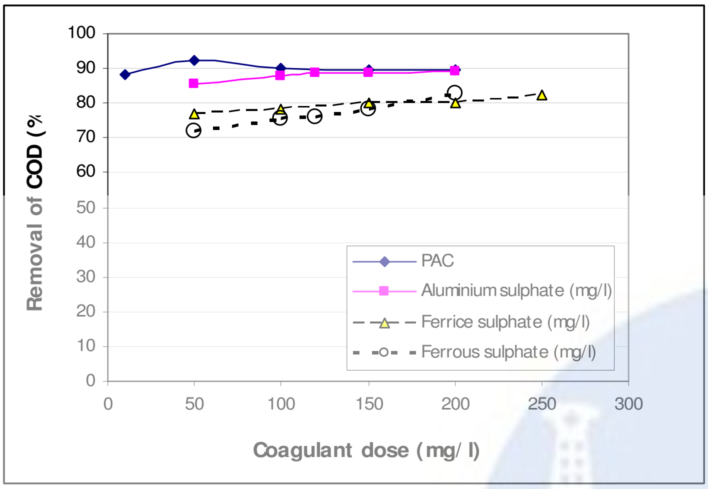

Fig 3: COD removal versus coagulant dose for different coagulant.

3- Sand Filtration

Sand filtration processes consist of a fixed bed of media that traps and removes suspended solids from water passing through the media. A gravity filter (height 1m and surface area of 20 cm2) filed with ..mm sand particles (60 cm height) on top of a 40 cm gravel bed was used in this research. The effluent of the above mentioned sedimentation reactor was passed through the sand filter. The suspended particles (oil + coagulants), which were not removed in the sedimentation phase, were trapped in the sand filter. The effluent from the sand filter had a uniform and good quality. The COD of the effluent was below 150 mg/L.

CONCLUSIONS

Percent removal of oil after each unite process is shown in Fig. 4. As Fig. 4 shows removals of oil from water after unite processes gravity oil/water separation, coagulation/flocculation/sedimentation, and sand filtration were about 60%, 96% and 98%, respectively. This proves that overall system were able to separate about 98% of the oil from oil/water mixture. Therefore, it is recommended that in case of oil spill at sea, the water's surface mechanically be skimmed, and the mixture of oil/water, be taken onto the recovery barge and delivered for treatment and reclamation. Using the above tested technologies more than 95% of oil can be separated from the oil/water mixture.

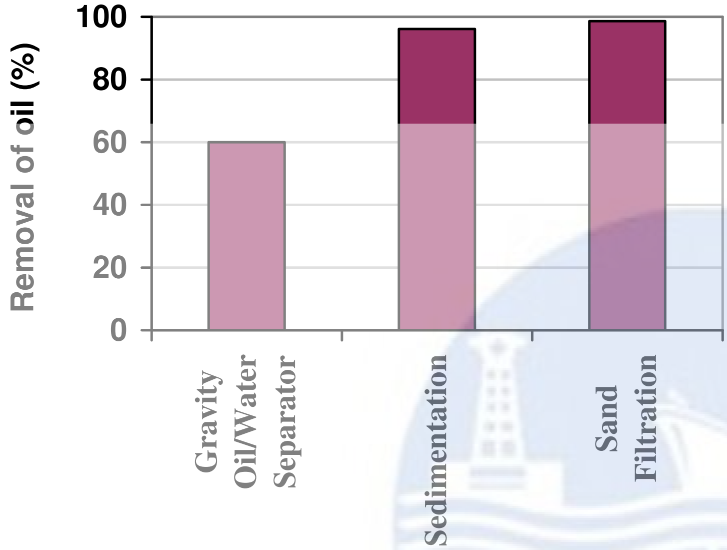

Fig. 4: Overall system performance.

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