Report On Bioremediation Of Oily Bilge Water Using BilgeRemed On M/V Cape Wrath

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Executive Summary

Sarva Bio Remed, LLC has completed a pilot study on M/V Cape Wrath to demonstrate that BilgeRemed, a bioremediation product is applicable for treatment of oily bilge wastewater on ships. M/V Cape Wrath is a Reduced Operational Status Ship (ROSS) of the Ready Reserve Fleet (RRF) being managed by Crowley Liner Services, Inc at their Baltimore, Maryland Port Facilities.

The results showed emulsification of bilge oil after addition of BilgeRemed followed by consumption of the floating oil resulting in reduced Total Petroleum Hydrocarbons (TPH) in the bilge water. Results of the first three weeks of treatment showed Total Petroleum Hydrocarbons (TPH) values of ***210, 240, and 5.5 ppm***. There was an increase in TPH values in the fourth week. This is attributed to the fact that the bilge tank was not freshly cleaned and was fouled with residual oil during its earlier operational duties elsewhere and to this is referred as the secondary source.

Evaluation of the fourth and fifth bilge water samples indicated that Bilge Remed remediated even this secondary source of oil. Final sample collected showed a reduced TPH value of ***65.7 ppm*** from ***424 ppm*** recorded previous week. This indicated that BilgeRemed reduce even the clingage oil. The studies were not continued beyond the five week period as was agreed. Another important finding is that the bilge water did not smell of hydrocarbons indicating reduction of fumes during treatment.

Introduction

All ships unlike medium and small boats, are equipped with bilge water treatment plant for separating water from oil prior to discharging into open waters. As per the international maritime law no ship can discharge untreated oily wastewater in open waters except through oil water separator equipped with oil content monitors. Only the waste water containing oil less than 15 ppm is allowed to be discharged. Bilge water treatment, due to the enforcement of maritime rules, is an operational problem for ships. In smaller boats, it is a normal practice to absorb oil on absorbent socks or pillows to absorb oil and these are later deposited at the port or a marina for final disposal. In either case, the responsibility of proper disposal of oily waste water lies with the operator.

The amount of bilge water produced by ships is directly proportional to the size and nature of operation of each ship. For example, an aircraft carrier produces on an average 3,000 gallons of bilge water a day during idle hours with a maximum of 25,000 gallons per day or 4.9 million gallons in one year. Other classes of Naval ships generate an average of 2,000 gallons per day totaling to 84.9 million gallons per year. Adding the total volume of 4.9 million gallons of Aircraft carrier fleet, the total volume of bilge water produced by the US Navy alone is 89.8 million gallons per year and this does not include oily waste produced in submarines. In general the amount of bilge water produced is quite high and therefore the maintenance thereof is quite an overhead for an organization.

Ship Managers such as Crowley Liner Services, Inc manage Reduced Operational Status Ships (ROSS) of the Ready Reserve Fleet (RRF) for US Maritime Administration (MarAD), which are ships that are berthed in harbor and generate limited quantities of oily waste. However, these ships cannot discharge bilge water containing oil within the local regulations, resulting in expensive disposal through private trucking.

Crowley Liner Services, Inc therefore, accepted our proposal for evaluating use of BilgeRemed on one of their nominated ships in Baltimore, to determine whether BilgeRemed will reduce the oil levels to zero ppm and facilitates overboard discharge without using pumps. M/V Cape Wrath was nominated for the trials in July 2003.

Project Background

Sarva Bio Remed, LLC thus submitted a proposal for a pilot study to demonstrate that BilgeRemed developed on the basis of patented biodispersion process is suitable for treatment of oily bilge wastewater on Reduced Operational Status Ship (ROSS) of the Ready Reserve Fleet (RRF) being managed by Crowley Liner Services, Inc at their Baltimore, Maryland Port Facilities. M/V Cape Wrath was nominated for the trial. The landmarks of the project are given below.

1. A bioremediation treatment plan and protocol were submitted on September 26th, 2002, and was accepted on November 26th, 2002 subject to certain conditions. Arrangements were made on December 4th, 2002, with Mr. Ricky Bullock, then Port Engineer, for initial sampling of Cape Wrath bilge water for chemical testing to determine if the water contained any compounds of toxic nature.
2. Independent laboratory chemical analysis of metals indicated the bilge water did not contain metals that would impede bacterial growth in general and of the bacterial consortium of BilgeRemed.
3. Initially, trial was scheduled in February 2003. The trial was postponed as the ship was called back into active duty.
4. The trial was rescheduled after the return of Cape Wrath to Baltimore port on June 6th. After consultation with Port Engineer, Mr. Willy Kirchner, fresh bilge water samples were collected for analysis of TPH.
5. Fresh BilgeRemed was manufactured and shipped to Cape Wrath and the project commenced on July 2nd.

Trial Parameters

Following information is required prior to initiating the treatment protocol.

1. Capacity of bilge tank
2. Volume of bilge water
3. Volume/thickness of floating oil in the bilge tank
4. Condition/history of tank (Has it been recently cleaned or painted)
5. Estimated amounts of oil clingage on the tank walls

Challenges

It was not possible to determine the exact volume of free-floating oil in the bilge tank at the start of the pilot study. According to the observation of the engineering personnel based on soundings that the oil layer may have be in the range of 2 to 4 inches thick. We tried to determine the thickness using a commercially available Oil Interface Monitor at the end of three weeks of trial and feel this can give a better indication than sounding alone but the results were not satisfactory.

Protocol for Treatment and Evaluation

At the end of the active duty of the ship, when M/V Cape Wrath returned to ROSS, the water sample showed the initial value of TPH as 49 ppm. The major amount of the oil had been discharged before its return to the port. The protocol for treatment adopted is as follows

1. Add 5 gallons of BilgeRemed in the bilge tank for 5 weeks.
2. BilgeRemed was added through the sounding tube.
3. Measure the volume of water and oil by sounding.
4. Determine oil thickness. (This was not done.)
5. Collect one sample every week for next day delivery to Sarva for analysis.
6. Sampling of bilge water was done through sampling port on every occasion.
7. ***5 gallons*** of BilgeRemed was added to the oily bilge tank through sounding pipe.
8. Record the sampling activity in the Evaluation sheet (Appendix A).

Sample Analysis

Samples received by Sarva will be analyzed for following parameters at our laboratory and also at an independent testing laboratory.

a. Amount of free oil
b. Microscopic observation of freshly received bilge samples
c. Total bacterial count through **Standard Plate Count (SPC)**
d. Total Petroleum Hydrocarbon content **(TPH)**

Pre- Trial Observations:

At the end of the active duty the ship returned back and was kept in the state of ROS. The water sample showed the value of TPH as 49 ppm. The major amount of the oil therefore had been discharged and part of the free floating oil may have remained clinging to the walls.

The sample of bilge water collected contained floating biofilm. The biofilm was examined under the microscope and found to contain a very large population of ciliate protozoa swimming in and out of the film (Figure 1).

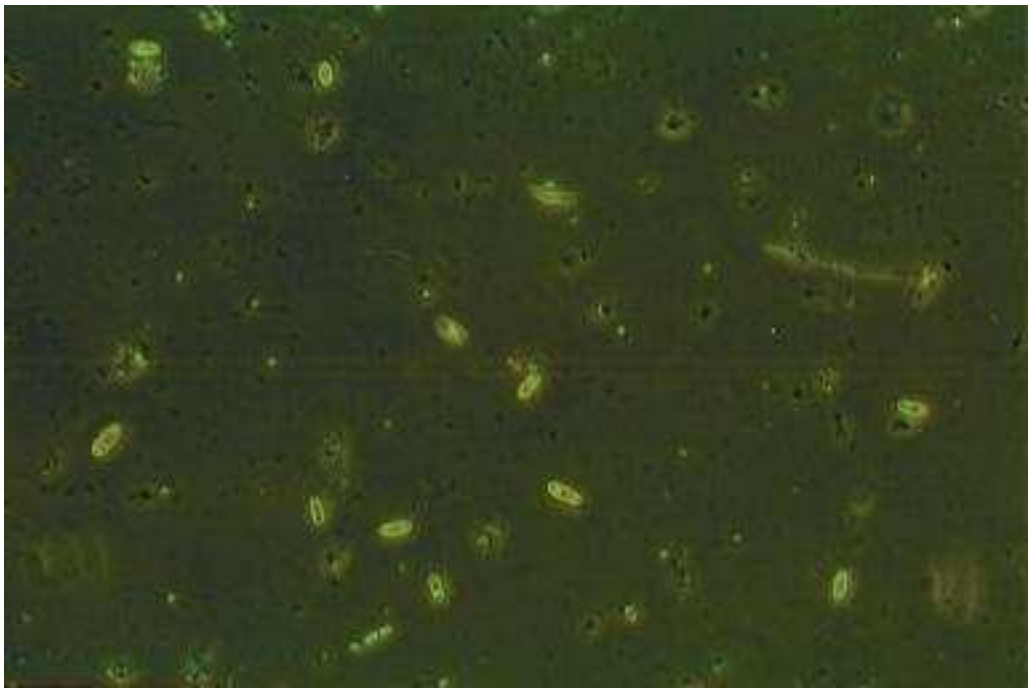


Figure 1: Ciliate protozoa (green objects) in bilge samples before treatment with BilgeRemed

Results:

Each sample received was subjected to visual and physical examination before the samples were sent to the analytical laboratory (Table 1). Physical and microscopic examinations are given below for each sample collected.

Samples of the bilge water sent to an independent laboratory for determining the values of Total Petroleum Hydrocarbons (TPH) in each sample and also the population of bacterial consortium, which constituted BilgeRemed. Results are given in Table 2.

Table 1. Observations of the bilge water samples:

Sample No.	Week (Date)	Free floatable oil (in %)	Color/clarity	Odor	Remarks
1	0 6/9/03 (Pre trial)	Not Determined	Clear	Hydrocarbon smell	Contained a large number of biofilm containing protozoan
2	1 (7/7/03)	2.5%	Brownish & Clear	Hydrocarbon smell	No biofilm, and no protozoa
3	2 (7/14/03)	0.68%	Clear	Hydrocarbon smell	No biofilm no protozoa
4	3 (7/21/03)	1.2%	Clear	No hydrocarbon smell	Stray protozoa
5	4 (7/28/03)	1.5%	Brown color with fine dark suspended particles	Hydrocarbon smell	No protozoa. Sample gave strong sulfide smell
6	5 (8/6/03)	1.6%	Brown color with many large dark brown suspended particles	Strong hydrocarbon smell	Particle appeared to be flaky and heavier than water.
7	6 (8/13/03)	1.5%	Clear	Hydrocarbon smell	A few large particles floating in water

Table 2. TPH values and bacterial count in each sample of bilge water

Sl. No.	Date	Week	TPH in ppm	Bacterial count/ml	Relative ratio of oil: Bacteria based on microscopy*
1	6/9/2003	0	49.0	N.D	N.D.
2	7/7/2003	1	211.0	5,200,000	3:1
3	7/14/2003	2	216.0	15,000,000	1:1
4	7/22/2003	3	5.3	1,520,000	1:3
5	7/28/2003	4	44.9	160,000	2:1
6	8/6/2003	5	424.0	90,000	2.5:1
7	8/13/2003	6	65.7	20,000	2:1

Microscopic examination of each sample as received was carried out and recorded photographically. Each photograph confirms the finding of the physical examination in Table 1. It is interesting to note that presence of free-living protozoa in the bilge water is considered as the indication of absence of hydrocarbon toxicity to these forms.

Sample 1:

There was no pre-trial sample of bilge water before the addition of BilgeRemed on July 2nd, 2003 as the data from the sample collected in June was considered as representative. There was no physical observation on the same.

Sample 2:

A sample of bilge water was collected the following week on 7th July, 5 days after addition of BilgeRemed. Another batch of 5 gallons of fresh BilgeRemed was added to the bilge tank after collection of the sample. The oil was in a dispersed state as can be seen in Figure 2. A large number of bacteria can be seen between and within the droplets.

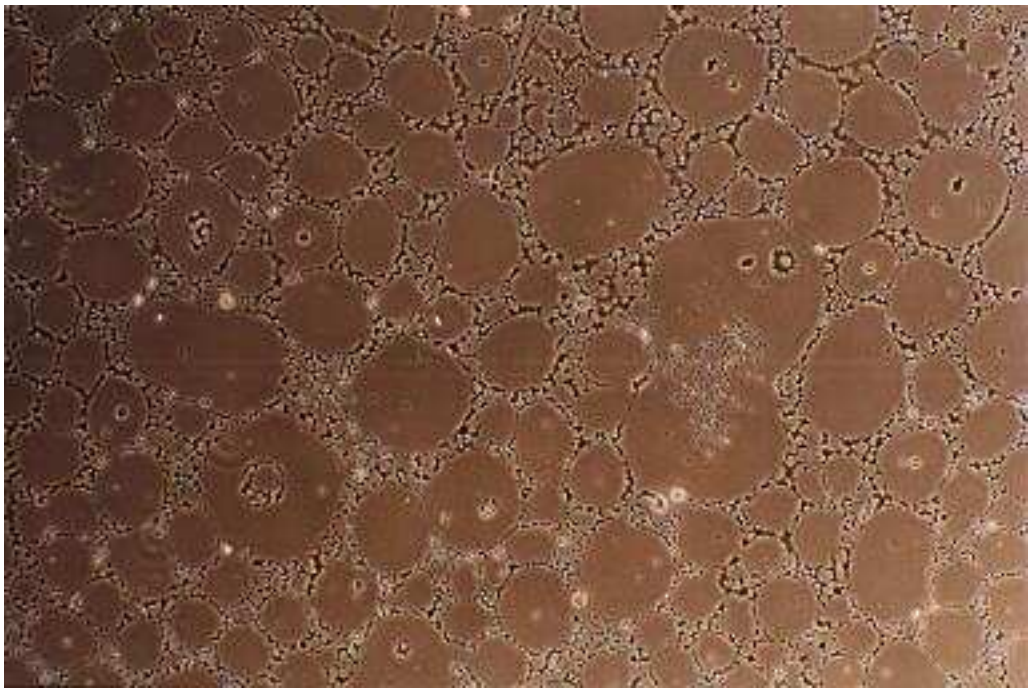


Figure 2: Sample showing emulsified oil and oil-eating bacteria 1 week after treatment

Sample 3:

Sample of bilge water was collected on 7/14/03 was also examined microscopically to determine changes taking place in the oil. The emulsified oil was not as densely packed as at the end of first week. Instead, there was an irregularly shaped emulsified oil droplet (Figure 4). Bacteria were predominantly associated with each oil droplet indicating their direct interaction with emulsified oil.

Sample 4:

This sample was collected on 7/21/03 before 3rd addition of BilgeRemed. There was no distinct hydrocarbon smell in the sample and the water appeared very clear. The sample when examined under microscope showed very few oil droplets as compared to both the samples after Week 1 and Week 2. Figure 5 shows a high bacterial population and low number of droplets of oil. The low number of droplets suggests that the bacteria have consumed the emulsified oil recorded in previous samples.

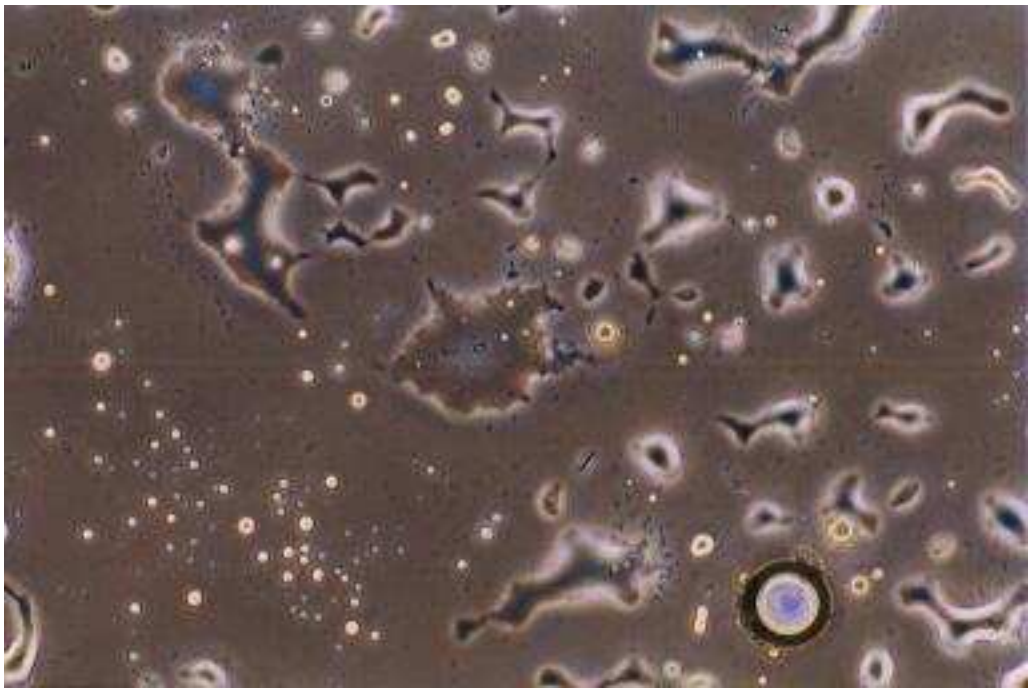


Figure 4: Oil-eating-bacteria in association with reduced amounts of oil droplets after 2 weeks of treatment

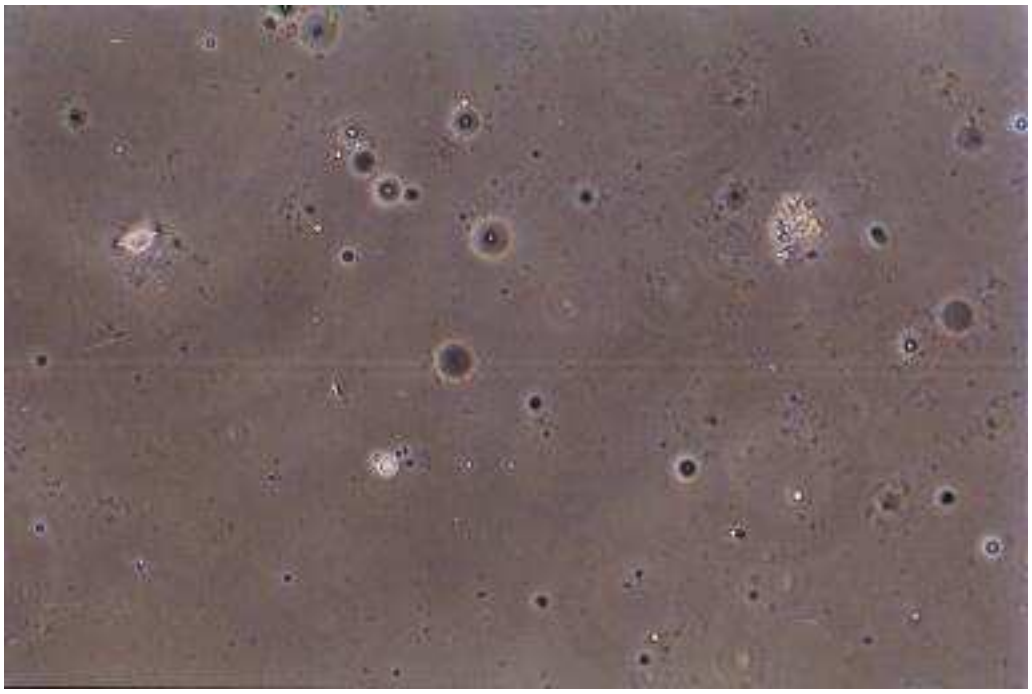


Figure 5: Large population of oil-eating bacteria associated with reduction of oil Week 3

Samples 5, 6 & 7

Remaining samples were evaluated microscopically that showed a large number of macroscopic particles and a heavy smell of hydrocarbon not observed in previous sample collected on 7/21/03. There were many particles that do not form a free oil layer and can be filtered out. Figure 6 is representative of these samples showing some of the particles but fewer live oil-eating bacteria.

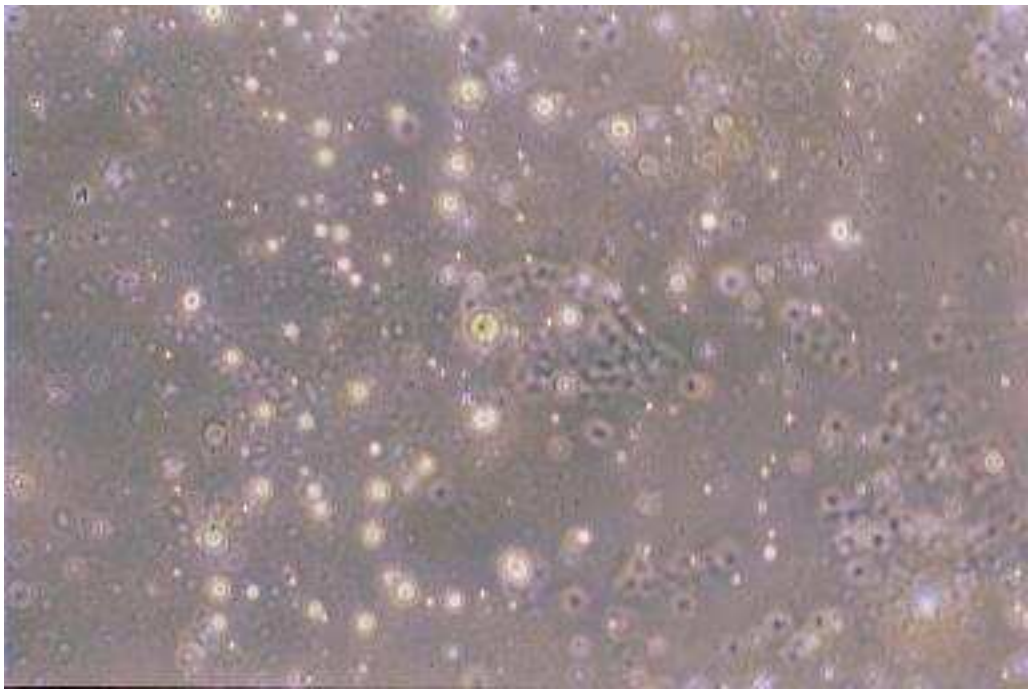


Fig 6. Presence of flaky particles indicating secondary source of oil

Discussions

The results of the shipboard trials carried out on Cape Wrath demonstrate that BilgeRemed effectively reduced the floating oil in the bilge tank 5.3 ppm of TPH. Moreover, the microscopic examination of the bilge water treated with BilgeRemed confirms the trend lines for TPH content and bacterial counts (Table 2).

This study has revealed that once the floating oil layer is consumed, a secondary source of oil in particulate form enters into the bilge water. This has been seen both from the visual inspection of the sample and from the elevated TPH levels recorded in the later samples. Even this source of "oil-clingage" is reduced by 80% in a very short period of time. The remarkable fact is that bioremediation by BilgeRemed was effective on both the sources of oil.

Is there a Diagnostic test for Bacteria in BilgeRemed?

A very important question is whether the bacteria in BilgeRemed are responsible in consuming the bilge oil and not the indigenous bacteria. Earlier laboratory studies have shown that the oil-eating bacteria stain red with the oil staining dye Oil Red O. Figure 3 shows that bacteria recovered from the bilge water sample stained red with Oil Red O indicating that the oil-eating bacteria in BilgeRemed are responsible for consumption of the bilge oil.

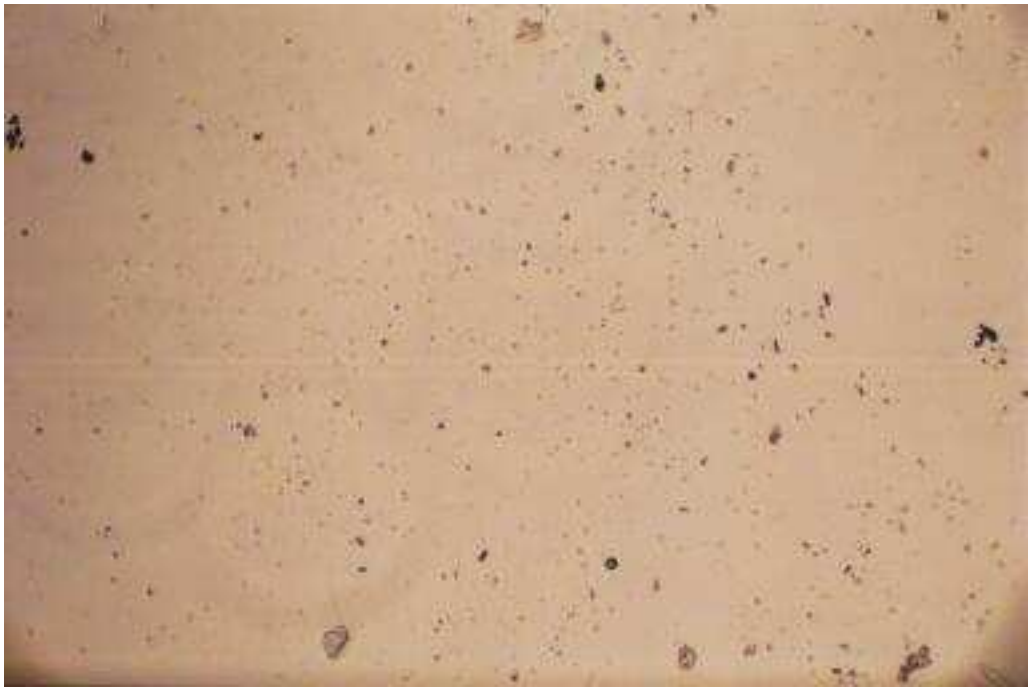
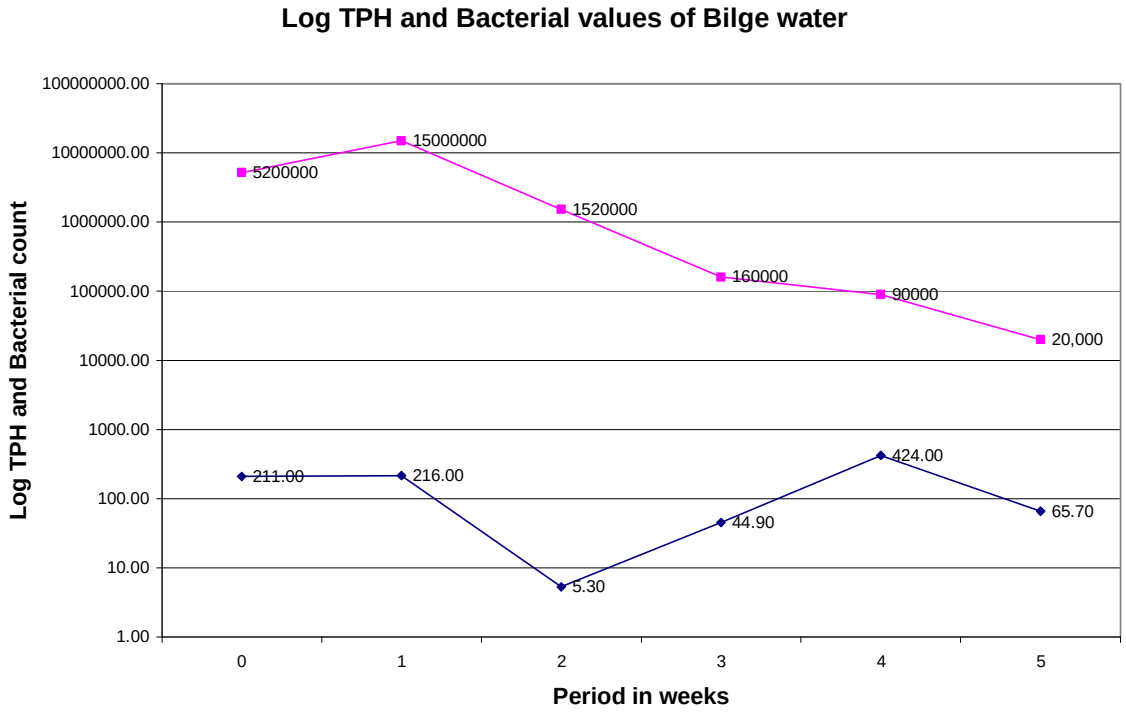


Figure 3: Oil eating bacteria and oil droplets colored red with oil red O Week 1.

TPH and Bacterial counts:

The total values of TPH recorded during the study period are given in table 2 above. The same is graphically represented below in Figure 7.



Effect on primary floating oil

It can be seen from the graph that although the value of starting TPH was 49 ppm the same value increased to more than 200 ppm after first addition of BilgeRemed. This is attributed to the action of BilgeRemed, which first disperses oil into small droplets to enable oil-acting bacteria to consume these oil droplets. The value was similar even in week 2 indicating that the process of biodispersion and bioutilization of floating oil was in progress. However this value was reduced to 5.3 ppm at the end of 3rd week before addition of 3rd batch of BilgeRemed. This reduction of TPH values is attributed to the consumption of floating oil in the bilge water.

Effect on secondary oil

The engineers on board Cape Wrath informed us, that every time one sample of bilge water is collected through the bilge pump, they discharge more than 50 to 100 gallons of bilge water in another tank. Level of bilge water is reduced progressively with every sampling exposing the walls of the bilge tank. These walls are likely sources of oil of secondary origin contributing to the new TPH values in bilge water. In above figure this is seen as the sudden increase of TPH value in week 4 and 5.

Conclusions

1. BilgeRemed is a fast acting bioremediation product that reduced the TPH content to 5.3 ppm in three weeks.
2. BilgeRemed can be used for pre-treatment of oily bilge in holding tank.
3. It reduces the odor of hydrocarbon effectively.
4. Results show that the bacteria in BilgeRemed participate in consumption of oil in bilge water. This confirmed by their specific staining and by their population densities.
5. Bacterial population decreases once free-floating oil is not available as food.
6. BilgeRemed is a cost effective solution for reduction of oil in bilge water on board ship for ships with and without Oil Water Separators (OWS).

Acknowledgements

We are thankful to Crowley Liner Services, Inc for giving us this opportunity of evaluating BilgeRemed on their ships. We are particularly thankful to Paul Varghese for actively supporting the trial.