Hull Cleaning Operation Efficiency in Containing Biological Material

Chandra Sekhar Mishra¹, Zenawi Fitwi², Habtom Imuru³

¹Lecturer Masawa College of Marine Science and Technology
²Graduate Assistant Masawa College of Marine Science and Technology
³Head of quality control lab

Introduction:

Historically hull fouling was a widely recognized and prominent vector, with descriptions of hull fouling in the literature going back to at least the early 1900’s – prior to the initiation of the use of seawater as ballast and when there was a predominance of wooden-hulled vessels (Minchin et al., 2006). The hull of a ship in contain biological material termed as bio fouling which leads to bio corrosion. Biofouling is defined as the attachment and growth of aquatic organisms on a total or partially submerged surface in an aqueous environment (M. Löschau et al., 2005).

Cleaning the hull of a ship has an important factor in the case of ship efficiency puzzle. The physical ability of the ship to overcome/encounter the wave acting, in streamlined manner has profound importance to fuel economy. Therefore, maintaining hull performance plays a great role, since a smooth hull is an optimally hydrodynamic hull. Modern empirical study of biofouling began in early 19th century with Davy’s experiment linking the effectiveness of copper to its solute rate (Woods Hole Oceanographic Institution, 1952).

In order to reduce accumulation of marine fouling on under water hulls, all world shipping industries both commercial and military use antifouling paint. This function is critical to reduce hydrodynamic drag of the hull and to maintain fuel efficiency of the ship. The growth and accretion of marine fouling highly depend on these factors: geographical location, time of year, temperature and salinity of water. Generally, biofouling is more aggressive in high water temperature areas, since it the prevailing condition for the breeding and growth fouling organisms. There are many additional variables, such as the availability of nutrients to support the fouling communities. Classic (Woods Hole Oceanographic Institution, 1952 et al 2009), reviews of marine fouling are available. In general, the longer a ship pier side, the more likely it is to accumulate fouling.

For convalescence of ship's performance, it is necessary to dry dock a ship and to proceed a clean off sea adherence. Before any other maintenance, activities following on, this cleaning is very essential. Nowadays under water cleaning is very
crucial, while considering the type of antifouling applied since cleaning in dry dock is not economical. Cleaning can be done manually in dry dock with an employment of different adapted methods like water jet or grit blasting. But it has to be noticed that, in itself, it is a very contaminant operation (the resulting dust always contains painting particles). It is harmful for operator’s health and it is a very uncomfortable job. Increased biofouling use due to biofouling contribute to adverse environmental effects and is predicted to increase emission of carbon dioxide and sulphur dioxide between 38 and 72 percent by 2020 (Salta et al., 2008).

Need for the Project Work:
Biofouling is one of the most important problems currently facing marine technology. In the marine environment any solid surface will become fouled. This results in higher fuel consumption and these results in a greater volume of greenhouse gases and other emissions being produced during the process of fuel combustion. In addition to fuel penalties in the short and long term, extensive bio-fouling will eventually lead to hull corrosion, which further compounds what was already a significant additional expense. The need of this project research paper is therefore to reduce biofouling taking place in the hull of ships, fishing vessel, tug boats by giving proper idea about the causes biofouling takes place in the hull of ships, fishing vessel, tug boats and to reduce improper way of biofouling prevention technique by describing all its harmful effect. In addition to this, to raise awareness, interest of the workers and to give attention in treatment of ballast water.

Statement of Problem:
Marine biofouling have a great effect in a ship in its overall efficiency and pollution of marine environment. In order to prevent or reduce these effects an effective method of hull cleaning and prevention technique is necessary. The cleaning technique which are used mostly in Massawa ship repair yard and in some other sites are not effective, because it does not exist for a long period of time and the paint they use here is copper based paint that have a very harmful effect in marine life. So effective hull cleaning method is needed in order to prevent a vessel from so many effects such as in increasing hydrodynamic drag, fuel consumption and reduced manœuvrevability of the vessel.

Objective of the Project Work:
- To investigate the fouling microorganism discharged from hull cleaning facilities available here without any treatment.
- To determine the causes and effect of fouling microorganism.
- To do brief survey of the biofouling prevention technique applied here.
- To give idea the harmful effects of improper way of biofouling prevention technique.
- To give idea new technique that can be applied here to prevent biofouling

Methodology:
Site Selection:
Three different places have been selected and visited for collecting data. These sites are Ghibi harbour, Ship repair yard and Massawa port. In ship repair yard there are many non-operational and few operational vessels, Ghibi (fishing vessels harbour) here also there are operational and non-operational fishing vessels and boats. Massawa port is the main berthing place for foreign merchant ships, local vessels, in which the loading and unloading of cargoes take place.

Data Collection:
This data collection is mainly based on primary and secondary data.

Primary Data:
1. By referring various books related to our project. Direct interview depending on questionnaires prepared.
To master

To Chief engineer

To crews Questionnaires prepared are:

i) What type of fouling paint is applied?

ii) After how long interval of time the fouling paint is applied?

iii) What type of cleaning technique done for cleaning the hull of a ship?

iv) After how long interval of time cleaning technique is applied?

v) What type of fouling organism mostly attached to the hull surface?

3. Observing and taking pictures.

Collecting information and taking photographs of fouled vessels by visiting to selected sites which are observable by our naked eyes.

Secondary Data:

It was collected from various materials such as internet, journals and previous research projects.

Collection of Water Sample (Ballast and Bilge)

Ballast water and bilge water samples were collected from selected sites to find total plate count (TPC). In this research we mainly focus on ballast water. Only ballast water was collected to identify the microorganisms carried in the ships ballast water. All water samples were aseptically collected in sterile 500ml capacity glass bottles, from the depth of 10-25 cm ballast tanks and from ballast pipe tap, while the sterile bottle held with calliper was lowered in to water depth to fetch the water samples. All bottles were well rinsed at least three times with the water being sampled before collection. Finally all the bottles kept in bags and transported to laboratory in an insulated container with ice with 24 hours of collection.

3.3.1 Total Plate Count Analysis (Pour Plate Method)

The TPC was done following EN ISO 6222: 1999 in quality control, Ghibi, MMR. For the enumeration of TPC, 1ml of each sample was placed in Petri dish without dilution and 9 ml of peptone water solution added to obtain a 10ml dilution. Total plate counts (TPC) counts were evaluated on plate count agar (PCA). Plates were incubated at 22°C and 37 °C for 24hrs. Colonies on plates that had grown were counted using colony counter and counts were multiplied with the relevant dilution factor.
TABLE 3.1 Availability of vessels on selected sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Operational vessel</th>
<th>Non-operational vessel</th>
<th>Tugboat</th>
<th>Pilotboat</th>
<th>Hull cleaning operation</th>
<th>Separation of solid and liquid</th>
<th>Disposal solid/liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship repair yard</td>
<td>2</td>
<td>12</td>
<td>NO</td>
<td>NO</td>
<td>Dry dock</td>
<td>NO</td>
<td>Landfill/Sea</td>
</tr>
<tr>
<td>Massawa port</td>
<td>10-12 monthly</td>
<td>NO</td>
<td>3</td>
<td>2</td>
<td>Diver Service</td>
<td>Yes</td>
<td>Landfill/sea</td>
</tr>
<tr>
<td>Ghibi</td>
<td>6</td>
<td>8</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>Landfill/sea</td>
</tr>
</tbody>
</table>

Analysis of Ballast Water for Identification:
To identify microorganisms present in ballast water that cause biofouling on the hull of the ship, three samples of ballast water collected from selected site of different ships have been taken to Asmara Ministry of Agricultural lab. From this three samples shown below the fouling organisms has been found that are Pseudomonas aeruginosa and aeromonas hydrophila.

Methods Used For Pseudomonas Aeruginosa Analysis:
Blood agar was used in isolating pseudomonas aeruginosa bacteria from ballast water samples. Isolation is done based on traditional method of bacterial isolation. 27 grams of the blood agar were suspended in 1 litre of distilled water in a conical flask. This was dissolved completely by boiling over a flame and sterilized by autoclaving at temperature 123°C for 15 minutes. This bacterial isolation is pour plate method. 100 ml ballast water sample from sterilized bottle of sample first pour into graduate cylinder. Then pour into 9ml of peptone water for dilution purpose. 1ml of diluted sample poured into sterilize Petri dish then blood agar is poured over it for sub culturing the bacteria. Then placed in the incubator at temperature 42°C then with (24-48) hours the presence pseudomonas aeruginosa has been found with the biochemical test. (It size, shape and motility….etc) and its general is identified with the help of microscope.

Method Used For Aeromonas Hydrophila Analysis:
Blood agar was used in isolating aeromonas hydrophila bacteria from ballast water samples. Isolation is done for this also based on traditional method of bacterial isolation. 24 grams of blood agar were suspended in 1 liter of distilled water in a conical flask. This also dissolved completely by boiling over a flame and sterilized by autoclaving at temperature 120°C for (15-20) minutes. This bacterial isolation also pour plate method. 100ml ballast water sample, poured into graduate cylinder. Then pour into 9ml of peptone water for dilution purpose. 1ml of diluted sample poured into sterilized Petri dish then blood agar is poured over it for sub culturing the bacteria. Then placed in the incubator at temperature (35-37)⁰c then with (24-48) Hours the presence pseudomonas aeruginosa has been found with the biochemical test. (It size, shape, motility ….etc) and its general nature is identified with the help of microscope.
Fig 3.3 samples collected from selected sites for identification of fouling microorganisms.

Fig 3.4 samples collected from Massawa port
Results and Discussion:

Result of TPC Analysis:

**Table 4.1 Result of TPC Analysis without treatment**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample</th>
<th>Method</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plate count (22⁰c)</td>
<td>Bilge water (ship yard)</td>
<td>EN ISO 6222:1999</td>
<td>100/ml</td>
<td>4 (10×10 /ml)</td>
</tr>
<tr>
<td></td>
<td>Ballast water #1 (Ghibi)</td>
<td>EN ISO 6222:1999</td>
<td>100/ml</td>
<td>4 (3,0×10 /ml)</td>
</tr>
<tr>
<td></td>
<td>Ballast water #2 (ship yard)</td>
<td>EN ISO 6222:1999</td>
<td>100/ml</td>
<td>4 (3,0×10 /ml)</td>
</tr>
<tr>
<td>Total plate count (37⁰c)</td>
<td>Bilge water (ship yard)</td>
<td>EN ISO 6222:1999</td>
<td>20/ml</td>
<td>4 (10×10 /ml)</td>
</tr>
<tr>
<td></td>
<td>Ballast water #1 (Ghibi)</td>
<td>EN ISO 6222:1999</td>
<td>20/ml</td>
<td>4 (3,0×10 /ml)</td>
</tr>
<tr>
<td></td>
<td>Ballast water #2 (ship yard)</td>
<td>EN ISO 6222:1999</td>
<td>20/ml</td>
<td>4 (3,0×10 /ml)</td>
</tr>
</tbody>
</table>

Total plate count (TPC) is done for the indication of microorganisms present in ballast water and also in bilge water. Three samples have been collected from selected sites, these are (one ballast and bilge water) have been taken from ship repair yard and only one ballast water have been taken from Ghibi. Based on the result, the total amount of microorganism present in ballast water from the two selected sites were found the same which is 3,0×10⁴ per millilitre that is out of the quality to be accepted or out of the standard level (according to quality control laboratory). Whereas, the bilge water sample collected from the ship found in ship repair yard were 10×10⁴ per millilitre, and this analysis is done at parameter of 22⁰c and 37⁰c. From the above table, it is shown the result of bilge water is three times more than that of ballast water. This research paper mainly focused in ballast water because ballast water is the one commonly and simply discharged to the sea without any treatment in these two selected sites. Whereas bilge water is not allowed to discharge simply to the sea but, it might be leak to the sea due accident.

**Table 4.2 Result of TPC analysis with treatment.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total plate count (22⁰c)</td>
<td>EN ISO 6222:1999</td>
<td>100/ml</td>
<td>0 /ml</td>
</tr>
<tr>
<td>Total plate count (37⁰c)</td>
<td>EN ISO 6222:1999</td>
<td>20/ml</td>
<td>4 (2,0×10 /ml)</td>
</tr>
</tbody>
</table>

The result shown above in table 4.2 was collected from foreign ship found in Massawa port. In this
vessel ballast water was treated before discharge to the sea using filter, the result at 22°C was 0/ml and at 37°C was 2, 0×10⁴/ml. By comparing this result with the analysis done without treatment the amount get reduced. The Main cause of more amount of TPC in ballast water and bilge water tank is, when water kept in tank for long period of time without cleaning or done any proper treatment. This enables the bacteria to grow in their numbers, due to this total plate count will be more and the ballast and bilge water will be fully contaminated. Effect of this ballast water will result in presence of pathogenic bacteria which cause disease like cholera, typhoid fever and dysentery. Even if accidental spills of bilge water which represents a relatively small source of oil, this directly affect birds and mammals and have devastative effects on local vulnerable economies. Oil float on top of water which prevents the light to reach bottom due to this marine plants can die, this results large effect in ecosystem.

Result of Analyzed Sample:

Results of those three samples analyzed in Asmara Ministry of Agriculture based on the request given are:

i. Aeromonas hydrophila
ii. Pseudomonas Aeruginosa

Result of those two samples analysed in Asmara national laboratory.

One sample water which has taken directly from Massawa port sea water the results are

Klebsiella pneumonia rhinosereamtis were isolated from ballast tank which has taken water from Massawa port (ballast#1).These microorganisms are very destructive. Whereas the second sample were taken from the ballast tank of the foreign vessel. As they use treatment before discharging the ballast water to sea, the result was zero which means no bacteria found.

Description of Selected Site Massawa Ship Repair Yard:

Ship repair yard is mainly used for repair and maintenance of different ships. In this place there are many operational and non-operational vessels. In this place hull cleaning operation takes place and there are many fouled ships which gets idle for a long period of time. Ballast water is freely discharged to the sea without treatment. On board of some of those vessels there are crew members living there just for watch keeping. All their waste food and sewage water are discharged to the sea. This makes more likely to accumulate fouling organism on hull of the ship.

Fig 4.1 Fouled ship in Massawa ship repair yard

2. Massawa Port:

This port accommodates international commercial ships and local operational vessels as well as three tug boats and two pilot boats. The number of foreign vessels which visit Massawa port monthly around 10–12. It was found from the result of ballast water sample collected from one of foreign ship in Massawa port which is tested in national laboratory and no fouling organism found. This shows that, the vessel uses ballast water treatment before discharge to the sea. The port authority should have to check that foreign vessels visiting this port, if they use ballast water treatment or not. The problem is with local vessels which discharge the ballast water without treatment.
3. GHIBI:
Ghibi harbour is the berthing place for all fishing boats and small local fishing boats owned by individual nationals. There are many operational and non-operational fishing boats which are fouled more while comparing to other site. In this place hull cleaning operation is not done like other site. Ballast water is discharged to the sea without treatment and few bilge water leak to the sea due to fouled hull and accident. Over all this shows awareness of the crew members towards hull fouling and its formation is less.

4.4 Causes and Effect of Growth of Aeromonas Hydrophila, Pseudomonas Aeruginosa and Klebsiella Pneumonia Rhinoscereamtis:
In ship repair yard ballast water is kept for a long period of time in ballast tank, so as the ballast water discharge from the ballast tank to the sea without any treatment, as there is formation of biofilm in the hull of the vessel since it is disabled or idle then this organisms can grow and attack on the surface of the vessel causes accumulation of biological material. As there is leakage of sewage water into the sea due to the external action of human being these microorganism can grow at the sea and attack the vessel around there. When ballasting sea water to the ballast tank and sailing the vessel to the other port or to her country. As the ballast water discharged without treatment from the ballast tank to the sea non indigenous species [NIS] can introduce to the new sea surface. It can be also due to discharging of waste foods and vegetables into sea water and due to not periodical cleaning of ballast tanks so this will suitable for their growth.

Effect of Fouling Microorganism:
For the identification of the fouling organisms, in ballast water, total five samples have been collected from the selected sites. The first three samples were analyzed in Asmara ministry of agriculture laboratory and the result of analysis are aeromonas hydrophila and pseudomonas aeruginosa. The second two samples have been analyzed in national laboratory and the result of analysis are Klebsiella pneumonia rhinoscereamtis. In general three organisms have been found and these organisms are very critical and cause the hull of the vessel or boat to be rough.

As the ballast water is allowed freely to discharge to the sea this tends to Cause biofouling or hull fouling. Ballast water is discharged freely without carrying out treatment and brief survey for ballast water especially, at Massawa port. As there is no inspection for treatment of ballast water then ,at the time of discharging with the presence of microorganisms, when new surface of hull or a jetty, or a raft - is placed in the marine environment,
this can be easily colonized by a variety of marine species. Although the majority of these fouling species are small-sized sedentary, burrow-dwelling or clinging species (Galil et al., 2002), they also include mobile species such as crabs, brittle stars and small fish, as well as parasites and diseases (Minchin, 2007a). The colonization process usually takes place as a succession, within minutes of the immersion of a clean surface in water; it adsorbs a molecular film consisting of dissolved organic material. The occurrence of biofilm on hull surface helps the aeromonas hydrophila and pseudomonas aeruginosa to strike the surface of the hull, that is called extracellular polymeric substance produced by those microorganisms and then colonized within hours by bacteria, and helps unicellular algae (especially diatoms) and/or cyanobacteria (blue-green algae) which together form a biofilm – an assemblage of attached cells, also called microfouling or slime (Callow et al., 2002). These microorganisms adhere to the surface by secreting sticky substances (extracellular polymeric substances (EPS)). The biofilm is thus a gel matrix comprising the microorganisms and the EPS, and changes the chemistry of the surface making it more amenable for the settlement of macrofouling species (Chambers et al., 2006). Attached macrofouling communities Pioneering macrofouling species include green filamentous algae, bryozoans, serpulid tube its biofilm the first to establish followed by the gradual development of macrofouling species. Due to the accumulation of these organisms the hull roughness tends to increase and exceeds the limited roughness. Due to increasing of roughness the hydrodynamic drag increases as the ship moves through water, this results enhancing fuel consumption. Over all hull performance will be affected, so make sure a ship’s hull is smooth and friction-free as far as possible. The ship hull designed and shaped to cut the sea water wave while in motion. As the roughness increase, fuel consumption will increase adversely and as the same time GHG emissions will increase. This microorganisms may get detached, contaminate the water and disturb the food chain by effecting marine environment and can decrease the lifetime of ship hull as it leads corrosion. Biofouling is also associated to bio corrosion of surfaces, reducing the lifetime of the structures under a marine environment, which is also promoted by the corrosive effect of sea water itself. Microbiological fouling should be strictly controlled since it can create microbial induced corrosion (MIC). For example, sulphur-reducing bacteria (SRB) come from the marine sediment and gain energy using electrons from the steel structures, chemically reducing the sulphate from the sea water to sulphide, causing the pitting corrosion of steel surfaces(L. D. Chambers, et al.). Finally over all this increase the maintenance cost and requires large amount of man power. Effect of Klebsiella pneumonia rhinoscreamatis can get detached from hull of ship which may also cause infection in human being and also disturb food chain.

**Theoretical Analysis:**

This Theoretical analysis describes to the effect of biological material on the hull of the ship and this effect arises due to the growth of fouling microorganisms on the hull of a ship. This vessel found in ship repair yard.

Name of ship =**YOHANA (RORO)** Length the of the ship =92.07m Width of the ship =18.02m

Light Weight of the ship without biological growth= 2033.6 tones.

Assume in the absence of hull fouling control systems, within one year of active service a vessel could have up to 150 kilogram (0.150 ton) of marine life per square meter attached to the hull. But this vessel is being idle for almost 8 years so it could also have more than 150kg.

Total weight of the ship is assumed after one year = 2033.6 ton + 0.150ton = 2033.75ton

The draft of the ship without biological material=4.21 meter.

The relative flow past in the bottom of ship is similar to flow past a flat surface. Assume the bottom of ship as rectangular shape.
When the surface is smooth the flow of the fluid is laminar but when it is rough the laminar boundary layer is converted to turbulent boundary layer.

This analysis shown below for a smooth surface that is in laminar boundary layer and consider dynamic viscosity=0.001, velocity of water=1.5 and density of sea water

\[ \text{Re} = \left( \frac{\text{density} \times \text{Velocity} \times \text{length}}{\text{Dynamic viscosity}} \right) = \left( \frac{\rho \times V \times L}{\mu} \right) = \left( \frac{1025 \times 1.5 \times 92.07}{0.001} \right) = 141557625 \]

\[ \text{CD} = \frac{0.455}{(\log_{10} \text{Re})^{2.58}} - \frac{1700}{\text{Re}} = \frac{0.455}{(\log_{10} 141557625)^{2.58}} - \frac{1700}{141557625} = \frac{0.455}{(224.344) - 0.0000120} = 0.0020 \]

Assume the water in the sea is moving at 1.5 m/s.

Drag force on the bottom surface of ship when the surface is smooth assuming the base of ship rectangular. So Area = Length × Width

\[ \text{FD} = \text{CD} \times \left( \frac{1}{2} \right) \rho u_0^2 A = 0.0020 \times \left( \frac{1}{2} \right) \times 1025 \times (1.5)^2 \times (92.07 \times 18.02) = 3826.30 \text{N} \]

This analysis shown below for a smooth surface that is in laminar boundary layer and consider dynamic viscosity=0.001, velocity of water=1.5 and density of sea water =1025 kg/m³

Consider the analysis shown below, when there is Drag force on the bottom surface of ship when the surface is rough assuming the base of ship rectangular plate Density of sea water assumed 1025 kg/m³

\[ \text{FD} = \text{CD} \times (1/2) \rho u_0^2 A \]

For flow on a completely rough plate, assuming the flow turbulent

\[ \text{Viscosity assumed} = 0.002 \text{L/viscosity} = 92.07/0.002 = 46035 \]

\[ \text{CD} = 1/ (1.89+1.62 \log_{10} (L/ \text{viscosity})) = 2.5 = 1/ (1.89+1.62 \log_{10} (46035)) = 0.0036 \]

\[ \text{FD} = \text{CD} \times (1/2) \rho u_0^2 A = 0.0036 \times (1/2) \times 1025 \times (1.5)^2 \times (92.07 \times 18.02) = 6887.34 \]

Power required to move this vessel when the bottom surface is smooth assumed=drag force× Velocity of ship

\[ \text{Power required to move this vessel when the bottom surface is smooth assumed} = 3826.30 \times 1.5 = 5739.45 \text{W} \]

\[ \text{Power required to move the this vessel when the bottom surface is rough assumed} = 6887.34 \times 1.5 = 10331.01 \text{W} \]

Increase in power required when the bottom surface is rough = 10331.01 - 5739.45 = 4591.56 W

% increase in power required = (4591.56/5739.45)×100 = 79.9%

Therefore based on the theoretical analysis the result of drag force due to increased hull roughness is greater than the result of drag force with acceptable limit of hull roughness. So due to this increased hull roughness:

- The Drag force on the hull surface is increased.
- Fuel consumption increased based on the interview done with them.
- The speed of the vessel/tug boat is reduced.
- The emission greenhouse gases are increased.

Based on the observation of tug boat while navigating at sea.

So based on these effects the efficacy of hull cleaning operation in containing biological material can be determined and realized. To overcome this effect shown above the hull surface should be cleaned. Cleaning of the hull can save large amount of money and reduce the overall operational expenses.

4.6 Prevention Technique in Massawa Ship Repair Yard:

From selected sites, prevention technique is mainly done in Massawa ship repair yard. In this place most of the ship are idle for a long period of time which are non-operational so they are more subjected to chances of growing fouling organisms. Biofouling is most important problem currently facing those ships and have a great effect on the performance of vessels. The prevention techniques...
which are applied in Massawa ship repair yard to prevent fouling of a vessel are physical and chemical method of hull cleaning.

Chemical Method:

It is an anti-fouling paint a specialized category of coating applied as the outer (out board) layer to the hull of the ship or boat, to slow the growth and/or facilitate detachment of fouling organisms. Antifouling paint applied in Massawa ship repair yard are JOTUN and HEMPLE which is biocidal antifouling paint and it is a copper based paint. If copper exceeded more than the standard it can harm marine life and release pulse of biocides in to sea water which disturbs the food chain. During the dry docking period of a vessel different operations are taken place. Removal of fouling organisms from the hull of a ship is one of the operation which is done during this period. Sometimes they also use in water cleaning method using scrapper to scrap the accumulated fouling organisms on the hull of the ship. During this operation copper based paints is easily removed since it is soft and release biocide which can harm marine life. And this prevention technique is applied at the interval of two years. Even though this technique is applied still, it harms marine environment and it is not effective.

Physical Method:

It is the simplest method for treatment of fouling, is simply to remove by mechanical cleaning. It includes scraping and sand blasting method of hull cleaning.

✔ SCRAPING

Surface cleaning by hand tools such as scrapers and wire brushes is relatively ineffective in removing mill scale or adherent rust. This equipment is used in Massawa ship repair yard to clean the hull surface. It requires great man power, Time consuming, and less effective. It is also not easily applicable to everywhere.

✔ SAND BLASTING

In Massawa ship repair yard this equipment is used to remove rust, fouling and prepare surface prior to downstream coating. The blast cleaning operation produces large quantities of dust and debris which must be removed from the abraded surface. There are many different hazardous situations and conditions created by blast cleaning operations such as dust, noise and chemicals. It require adjustment in pressure always.

New Prevention Technique Physical Method:

As discussed above, the cleaning mechanism applied in Massawa ship repair yard have side effect in overall efficiency of the ship and marine environment. It is also inadequate for existence of the vessel and to achieve the desire effect to ensure safety, efficiency, reduced fuel consumption. To overcome those effects, improvement in hull cleaning and prevention technique is necessary. In water cleaning is one type of physical hull cleaning method which is done with help of multi brush machines such as scamp, mini pamper, brush kart and other designs. In water cleaning methods have been developed to remove marine fouling from ships during their service period between dry-docking. The majority of these methods use diver-operated machines fitted with rotating brushes. These systems can be used on steel, aluminium or composite hulls. Their limiting factor is curvature of the hull, larger cleaning devices cannot be used on smaller ships with a radius under 10 feet (3m) or on yachts due to their small area and curvatures. These multi-brush machines are supplemented by single brush machines that divers use for cleaning areas of higher radius that the multi-brush machines cannot reach. Multi-brush machines have wheels that drive and steer the unit along the hull, and also serve to maintain a constant height for the cleaning brushes. The machine is placed on the hull by divers, and adheres to the hull either by the use of an impeller creating suction against the hull or by the vortex action of the rotating brushes.
Chemical Method:

Antifouling paint used in Massawa ship repair yard is copper based, this leaches toxic pulse of biocides to the sea and have great effect in marine living organisms. Applying or using of the most efficient and nontoxic antifouling paint with low cost of and longer life span will solve the problem created with copper based paints. Those Paints are Tin free self-polishing copolymer (SPC) and Ecospeed.

**TIN Free Self-Polishing Copolymer (SPC):**

Using tin free self-polishing copolymer (SPC) which is basically designed to be smooth and rough so the biofouling sea growth will be released from the hull rather than stick to it, and also will be easily cleaned so will minimize the sandblasting in shipyard which is also considered pollutant to environment.

**Ecospeed:**

It is hard coating Surface Treated Composite (STC) which is product of Hydrex Company. It is the original hard, non-toxic coating system for underwater hulls. Ecospeed was developed starting in 1994 and has been adopted by shipping line in all major sectors of operation since 2002. Ecospeed does not offer conventional biocidal anti-fouling properties and Hydrex suggests that in-water cleaning of the hull should be conducted regularly, the frequency to be determined by the ship’s operating pattern and local water conditions. Because of the product’s non-toxic and non-metallic properties, this type of cleaning can occur even in ports with the strictest environmental regulations. Ecospeed has proven to be a superior protection against ice and has had great success with icebreakers and ice-trading ships. Lloyd’s Register has certified Ecospeed for ice going ships, and permits a reduction of thickness of the steel plating in way of the ice belt of up to 1 mm where Ecospeed is used as the coating. Ecospeed is also particularly suitable for offshore vessels or those that are often stationary and not dry docked very often since the coating can be cleaned under water as aggressively as needed to bring it back to its original pristine condition without fear of damaging the coating or harming the environment. It is also used by major ferry lines, cargo vessels, cruise operators, navies and others. The coating is classified as a Surface Treated Composite (STC),
which consists of relatively large glass flakes in a resin base. Once conditioned by an in-water process involving special tools, the coating provides a very smooth, extremely hard protection for the life of the hull, guaranteed for at least 10 years, requiring only minor touch-ups during routine dry-docking. Unlike conventional anti-fouling and foul-release coatings which markedly deteriorate as a ship ages, Ecospeed becomes smoother and achieves maximum hull efficiency and fuel savings through routine in-water cleaning. Due to Ecospeed’s environmental safety, in-water cleaning of ships coated with Ecospeed is approved in ports where in-water cleaning is normally banned. As part of an EU-LIFE demonstration project in 2008, stringent tests proved that the Ecospeed coating is 100% non-toxic with no negative effect on water quality or the marine environment at any point of its use or application. The product was awarded the 2012 National Energy Globe Award for sustainability.

**Theoretical Analysis of the Prevention Technique:**

This theoretical analysis shown below describes the treatment or separation of solid or liquid wastes with the effect of gravity. Liquids with a specific gravity or relative density difference can be separated in a ballast tank by the effect of gravity and the process can be represented mathematically by

\[
\text{FS} = \frac{\pi}{6} D^3 \left( \rho_{\text{Solid}} - \rho_{\text{Water}} \right) w^2 r = \frac{\pi}{6} D^3 \left( 1442 - 1025 \right) \left( \frac{v^2 r^2}{r^2} \right) = \frac{\pi}{6} D^3 \left( 1442 - 1020 \right) \left( v^2 r^2 \right) \left( \frac{r}{r} \right)
\]

Diameter of rotating basket of centrifugal filter = 0.180 meter taken from ship visited

Radius of blade of centrifugal filter = 0.007 meter taken from ship visited

\[
FS = \frac{\pi}{6} D^3 \left( \rho_{\text{Solid}} - \rho_{\text{Water}} \right) w^2 r = \frac{\pi}{6} D^3 \left( 1442 - 1020 \right) \left( \frac{v^2 r^2}{r^2} \right) \left( \frac{r}{r} \right) = \frac{\pi}{6} (0.180)^3 \left( 1442 - 1020 \right) \left( 13.602 / 0.007 \right) = 33650.24 N
\]

Centrifugal filter should be used along with heater to prevent biofouling in the hull of ship as they exert more force to separate solid from liquid are to the separation force due to gravity.

**Conclusion:**

As this biological material led to detractive consequence which is bio corrosion to operational and non-operational vessels placed in the selected sites, due to this bio corrosion the physical property of the ship get changed. In order to reduce the harmful effect of biofouling a great care of a ship and marine environment should be done. A ship should not be allowed to leave port until and unless it is properly cleaned. There should be under water surveyor to check whether hull is properly cleaned or not without which ship should not be allowed to leave the territory water. Proper survey should be done on the ballast water treatment applied by a foreign and local ship after ballasting and before de-ballasting.

Therefore, some drastic change should be done in Massawa ship repaired yard that is new prevention technique. Therefore it has been concluded that Ecospeed and tin free self-polishing copolymer coating are better way to control biofouling problem. Proper survey should be done on the types of paints applied in the hull of ship before ship leaves port. It can be concluded that no related progress to efficacy of hull cleaning operation in containing biological material has been done before.

**Reference:**

1. AMBIO (2008) Advanced Nanostructured Surfaces for the Control of Biofouling


