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Analysis of Decrease in Sewage Treatment Plant Performance at Mt. Swordfish

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ABSTRACT

The research results showed that the decline in STP performance was influenced by a lack of air supply in the tank due to a malfunctioning aeration blower/compressor, preventing aerobic bacteria from surviving. Furthermore, the suboptimal use of chlorine tablets also resulted in in effective processing. Another contributing factor was the crew's lack of knowledge and awareness of STP maintenance and understanding of the types of waste that should be managed. Then the efforts that can be made to overcome the problem of pollution in the sea that originates from Sewage Treatment Plant (STP) namely by carrying out regular maintenance on Sewage Treatment Plant (STP) according to the procedures contained there in manual book and also socialization to the crew, both maintenance and also types of waste that can or cannot be managed.
Keywords: Sewage Treatment Plant, Waste, Marine Pollution.

ABSTRAK

Hasil penelitian menunjukkan bahwa menurunnya kinerja STP dipengaruhi oleh kurangnya suplai udara di dalam tangki akibat aeration blower/compressor yang tidak bekerja dengan baik, sehingga bakteri aerob tidak dapat bertahan. Selain itu, penggunaan chlorine tablet yang tidak maksimal juga menyebabkan proses pengolahan tidak berjalan efektif. Faktor lain yang turut berpengaruh adalah minimnya pengetahuan dan kepedulian awak kapal terhadap perawatan STP serta pemahaman mengenai jenis limbah yang seharusnya dapat dikelola. Kemudian upaya Upaya yang dapat dilakukan untuk mengatasi masalah pencemaran di laut yang berasal dari *Sewage Treatment Plant (STP)* yaitu dengan melakukan perawatan secara berkala pada *Sewage Treatment Plant (STP)* sesuai dengan prosedur yang ada di dalam *manual book* dan juga sosialisasi terhadap crew baik perawatan dan juga jenis limbah yang dapat ataupun tidak bisa dikelola.
Kata kunci: Sewage Treatment Plant, Limbah, Pencemaran Laut.

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1. INTRODUCTION

Ships play an important role in transportation and the economy, so they require auxiliary equipment to maintain the survival of the crew and prevent marine pollution, one of which is the Sewage Treatment Plant (STP) according to Annex IV MARPOL. STP processes biological waste such as feces and urine using aerobic bacteria with a continuous oxygen supply so that the discharge meets the eligibility standards. Disposal of waste without treatment can reduce water quality, damage the ecosystem, and cause health impacts. Therefore, the performance of the STP must be maintained, but in marine practice at MT. SWORDFISH the author found problems in the form of blower damage, clogged air diffusers, and less than optimal use of chlorine tablets, which became the basis for compiling a thesis entitled "Analysis of the Declining Performance of the Sewage Treatment Plant on the MT. SWORDFISH Ship".

2. METHOD

This study used qualitative methods with observation, interviews, and literature review to analyze the causes and impacts of declining Sewage Treatment Plant (STP) performance on the marine environment. The study was conducted on the MT Swordfish for approximately one year, with the STP's auxiliary machinery used to process the ship's wastewater.

Primary data was obtained through direct observation, interviews with engineers, and documentation of problems that arise at the STP, while secondary data came from books, journals, digital sources, and ship manuals. Data analysis was conducted descriptively qualitatively by applying the urgency, seriousness, and growth (USG) method to determine problem priorities, thus obtaining a comprehensive picture of the operational system, obstacles faced, and solutions to prevent marine pollution through proper maintenance and operation of the STP.

3. RESULTS AND DISCUSSION

3.1 Research Results

1. A brief history of MT. SWORDFISH

   MT. Swordfish is a Marshall Island-flagged Aframax tanker with a GT of 62,371, a double hull, ABS-classified, and operated by PT Buana Lintas

Lautan on international routes. This vessel is equipped with a modern navigation system, equipment according to international standards, and various auxiliary machinery to support operations and prevent marine pollution according to MARPOL. One of the important machinery is the Sewage Treatment Plant (STP) which treats waste from toilets, galleys, and hospitals before being discharged into the sea to maintain the sustainability of the marine environment.

Figure 1. MT SWORDFISH

2. Sewage Treatment Plant

*Sewage Treatment Plant (STP)*The MT.SWORDFISH used in this study has the following specifications:

Sewage treatment plant	:	Sasakura hamworty
Unit type	:	ST-3A
Purification process	:	Activated sludge aeration process
Rated number of person	:	38 person/day
BOD	:	Dibawah 40 PPM
Suspenden solid	:	Dibawah 40 ppm
Coliform fecal	:	Maximum 200 per 100ml
Power source	:	AC 440 Volt, 60 Hz
Compressor udara	:	1 unit
Pompa pembuangan	:	1 unit
Air diffuser	:	2 unit

Figure 2. STP specifications on MT. SWORDFISH

Figure 3. Sewage Treatment Plant MT.SWORDFISH

3. Procedures for running and shutting down the Sewage treatment plant

Sewage Treatment Plant (STP) operational procedures are crucial for maintaining performance and preventing marine pollution, and therefore must be adhered to by the ship's crew. During operation, the body, blower, discharge pump, and valve are checked for leaks; the blower, pump, and panel are operated according to standards; air pressure and discharge are ensured to be normal; chlorine tablets are refilled daily; and the return line is checked. The STP may only be shut down outside 12 nautical miles of land, at a minimum ship speed of 4 knots, and not in a special area. The steps include diverting wastewater overboard, waiting for the level to drop, then shutting off the blower, panel, and closing the valve. During operation, BOD and COD tests are conducted using waste samples with chemical tablets according to standard procedures.

4. Sewage Treatment Plant performance standards

The performance of a ship's Sewage Treatment Plant (STP) is assessed based on the quality of the wastewater and the technical condition of the equipment. Normal performance is achieved when the wastewater meets MARPOL Annex IV standards, namely BOD <25 mg/l, COD <125 mg/l, and does not change the color of the sea, with a compressor blower pressure of 0.1–0.5 kg/cm² and a pump discharge of 1.4–1.8 kg/cm². Conversely, abnormal performance is characterized by wastewater parameters exceeding standards or equipment pressures outside operational limits,

which are usually caused by aeration disorders, blockages, or mechanical problems. Regular monitoring is required for the STP to function optimally and prevent marine pollution.

5. Administration of Chlorine, acidifying, and permanganate tablets

   In the final stage of wastewater treatment on board ships, chlorine, acidifying, and permanganate tablets are added to ensure the waste meets standards before being discharged into the sea. Chlorine tablets function as disinfectants with a residual of 5 mg/L, and at the Sasakura Hamworty STP type ST-3A with a capacity of 2,310 L/day, the practical requirement is 1 tablet (20 g, 65% active chlorine) per day. Acidifying tablets are used when the pH of the waste is too high, to keep it in the optimum range of 6.5–7.5 so that the effectiveness of chlorine is maintained. Meanwhile, permanganate tablets function as additional oxidizers to reduce odor and accelerate the oxidation of organic matter, with a practical requirement of 1 tablet (5 g) for a volume of 2,310 L at a concentration of 2 mg/L. These tablets are administered at different points, namely acidifying and permanganate in the aeration tank, while chlorine tablets are in the final tank (chlorination tank).

6. Factors causing a decline in Sewage Treatment Plant performance

   The decline in Sewage Treatment Plant (STP) performance at MT. SWORDFISH is caused by four main factors: machines, materials, people, and methods.

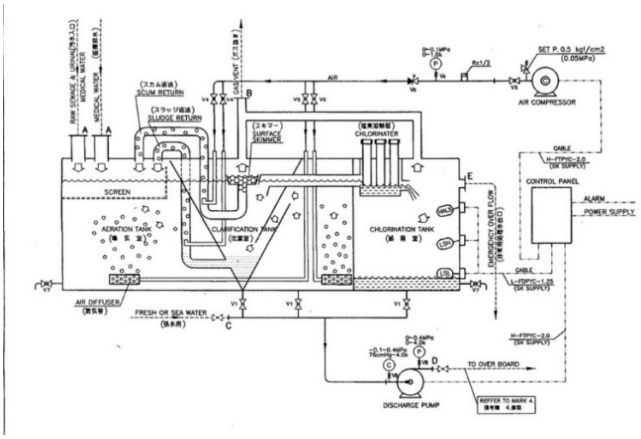

Figure 5. Circulation in Sewage Treatment Plant

Waktu	Kondisi	Tekanan (kg/cm²)	Status	Keterangan
2024-02-15 07:00	Normal Operation	0.3	Normal	Tekanan dalam batas normal (0.1 – 0.5 kg/cm²)
2024-02-16 09:00	*Air Diffuser* Mampet	0.85	Abnormal	Tekanan naik di atas normal, indikasi diffuser tersumbat
2024-02-16 09:30	Tindakan Pembersihan	-	-	Dilakukan pembersihan diffuser, kompresor dimatikan sementara
2024-02-16 14:30	Setelah Pembersihan	0.32	Normal	Tekanan kembali normal setelah diffuser dibersihkan

Figure 6. Blower Pressure Gauge at the time of the incident

Waktu	Kondisi	Tekanan (kg/cm²)	Status	Keterangan
2024-02-15 07:00	Normal Operation	1.6	Normal	Tekanan dalam batas normal (1.4 – 1.8 kg/cm²)
2024-02-16 09:00	Proses aerasi tidak sempurna	2.0	Abnormal	Tekanan naik di atas normal, indikasi proses aerasi tidak sempurna
2024-02-16 09:30	Tindakan Pembersihan	-	-	Dilakukan pembersihan diffuser, pompa dimatikan sementara
2024-02-16 20:30	Setelah Pembersihan	1.5	Normal	Tekanan kembali normal setelah diffuser dibersihkan

Figure 7. Pressure gauge discharge pump at the time of the incident

Tanggal	Waktu	Lokasi Sampling	BOD (mg/L)	COD (mg/L)	Keterangan
14/02/2024	08:00	Discharge pump	22	110	Normal – Sistem aerasi berfungsi optimal
15/02/2024	08:00	Discharge pump	24	118	Normal – Tidak ada gangguan
16/02/2024	16:00	Discharge pump	35	160	Air diffuser tersumbat – Aerasi tidak berfungsi
16/02/2024	16:30	Masinis 2 menambahkan 1 tablet permanganate tablet pada tangki aerasi yang berfungsi sebagai oksidator tambahan dan menurunkan COD			
17/02/2024	16:00	Discharge pump	26	135	Aerasi mulai pulih – Masih di atas ambang batas
20/02/2024	16:00	Discharge pump	23	120	Sistem aerasi normal kembali – Kualitas limbah sesuai baku mutu

Figure 8. Test kit results at the time of the incident

Figure 9. The author cleans the Aeration Tank

From the machine side, improper waste clogging into the tank causes the diffuser to become clogged, compressor pressure to increase, aeration to be disrupted, and waste quality to decrease.

Figure 10. V-Belt Blower compressor

Waktu	Kondisi	Tekanan (kg/cm²)	Status	Keterangan
2024-03-03 07:30	Normal Operation	0.45	Normal	Tekanan dalam rentang normal (0.1 – 0.5 kg/cm²)
2024-03-03 10:00	Setelah V-belt Kompresor Putus	0.0	Abnormal	Tekanan turun drastis, ditemukan v-belt kompresor putus
2024-03-03 10:15	Perbaikan Dilakukan	-	-	Kompresor dimatikan, penggantian v-belt dilakukan oleh masinis
2024-03-03 11:30	Setelah Perbaikan	0.42	Normal	Tekanan kembali stabil setelah penggantian v-belt

Figure 11. Blower pressure gauge when the compressor v-belt breaks

Tanggal	Waktu	Lokasi Pengambilan Sampel	Hasil BOD (mg/L)	Hasil COD (mg/L)	Keterangan Teknis	Tindakan Perbaikan
2024-03-03	08:00	Discharge pump	24	118	Mulai terdengar suara abnormal pada kompresor	Pemeriksaan awal dilakukan
2024-03-03	11:00	Discharge pump	28	135	V-belt kompresor putus, aerasi tidak berfungsi	Penggantian v-belt dijadwalkan
2024-03-05	08:00	Discharge pump	31	142	Aerasi belum berfungsi, terjadi penumpukan lumpur	Pemasangan v-belt baru dilakukan
2024-03-05	08:30	Masinis 2 menambahkan 1 tablet permanganate tablet pada tangki aerasi yang berfungsi sebagai oksidator tambahan dan menurunkan COD				
2024-03-10	08:00	Discharge pump	26	130	Aerasi mulai pulih, efisiensi pengolahan meningkat	Monitoring intensif dilakukan

Figure 12. Test kit results when the compressor v-belt breaks

Material factors arise when components fail to function optimally, such as a broken compressor V-belt, which cuts off the air supply, killing aerobic bacteria and ineffective waste processing. Human factors relate to the crew's lack of attention and awareness of STP maintenance according to the PMS and weak monitoring of marine pollution.

Tanggal	Waktu	Lokasi Pengambilan Sampel	BOD (mg/L)	COD (mg/L)	Keterangan Teknis	Tindakan Perbaikan
2024-07-10	08:00	Discharge pump	22	110	Operasi normal, sistem klorinasi berfungsi optimal	-
2024-07-30	08:00	Discharge pump	24	118	Penurunan jumlah tablet klorin terdeteksi	Peringatan diberikan kepada kru
2024-08-05	08:00	Discharge pump	30	135	Kadar klorin rendah, desinfeksi tidak optimal	Penambahan tablet klorin dilakukan
2024-08-07	08:00	Discharge pump	26	130	Sistem klorinasi mulai pulih	Monitoring intensif dilakukan
2024-08-29	08:00	Discharge pump	23	120	Sistem kembali normal, parameter dalam batas aman	-

Figure 13. Some test kit results when passing through the Red Sea

The decline in STP performance is caused by the irregular administration of chlorine tablets and inappropriate dosages, resulting in waste that does not meet standards and has the potential to pollute the sea.

7. Prevention efforts

NAMA BARANG	BOLEH DIBUANG	TIDAK BOLEH DIBUANG
Limbah feses manusia		
Sampah plastic		
Puntung rokok		
Kain/majun		
Biji-bijian		
Limbah hospital		
Limbah makanan *galley*		

Figure 14. List of items that are allowed and not allowed

Figure 15. Oiler inserts Chlorine tablet

Efforts to prevent a decline in STP performance at MT. SWORDFISH were carried out through several steps. First, socialization to all crew members regarding toilet cleanliness and the rules for items that may or may not enter the sewage line to prevent pipe blockages and system damage.

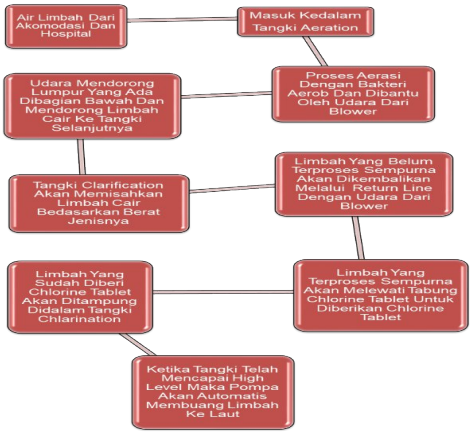

Figure 16. Sequence of waste management processes

Second, maintaining the quality of wastewater by providing chlorine tablets regularly according to the daily schedule, accompanied by the appointment of a responsible crew and the use of a daily checklist to ensure the correct dosage. Third, maintaining the performance of the blower compressor with maintenance according to the PMS, including cleaning the air filter and replacing the v-belt if it is loose or damaged, as well as maintaining other components so that the air pressure is stable and the aeration process is optimal. In addition, waste disposal is carried out according to regulations, namely to the aft peak tank when the ship is in port, and directly to the sea only when the ship is more than 12 miles from land with a minimum speed of 4 knots.

b. Sewage Treatment Plant Maintenance

Maintenance of the Sasakura Sewage Treatment Plant (STP) at MT. SWORDFISH based on the Planned Maintenance System (PMS) is divided into routine and periodic maintenance. Routine maintenance includes daily checking of the compressor pressure gauge to maintain it within the range of 0.1–0.5 kg/cm², checking the sludge return line to avoid blockages, and administering chlorine tablets as needed. Weekly to monthly periodic maintenance includes testing the waste quality with a test kit (BOD <25 mg/L and COD <125 mg/L), cleaning the chlorine tank, and checking the pump mechanical seal. Every three months, the aeration and clarification tanks are cleaned, while six-monthly maintenance includes checking the blower gear oil and lubricating the compressor bearings.

MAINTENANCE CHECKLIST	DAILY	MONTHLY	EVERY 3MONTHS	EVERY 6MONTHS	EVERY YEARS
Check Pressure Dari Udara Compressor	■				
Check Pipa Sludge Return	■				
Memberikan Chlorination Tablet	■				
Check Kebocoran Pada Pompa Discharge		■			
Pembuangan Sisa Limbah Yang Ada Pada Aeration Tank			■		
Pembersihan Pada Clarification Tank			■		
Memberikan Oli Dan Grease Pada Kompressor				■	
Pemeriksaan Pada Body Sewage Dan Juga Bagian Dalam Tanki					■
Membersihkan Bagian Intake Udara Dan Memperbarui V-Belt Pada Kompressor					■

Figure 17. Sewage maintenance schedule

Annual maintenance focuses on inspecting the STP body and air intakes. All of this maintenance is aimed at ensuring optimal STP performance and compliance with international environmental standards.

c. How to improve the quality of waste before it is discharged into the sea

If the wastewater test results exceed the quality standards (BOD > 25 mg/L, COD > 125 mg/L), improvements are made by optimizing aeration by checking the compressor blower, air diffuser, and tank cleanliness. Biological conditions are maintained by routine sludge cleaning, adding acidifying tablets to lower the pH, or permanganate tablets to increase microbial activity. Wastewater quality is also improved by improving sludge circulation, administering chlorine tablets according to the dosage, and maintaining pumps and pipes to ensure normal operation. The entire process is monitored using a sewage test kit and recorded in a sewage record book in accordance with MARPOL Annex IV.

4. CONCLUSION

Based on the results of observations and interviews, the decline in the performance of the Sewage Treatment Plant (STP) on the ship was caused by a lack of air supply to the tank due to suboptimal aeration compressors, irregular administration of chlorine tablets, and the entry of unprocessed waste which clogged the air diffuser and pipelines.

Preventive measures can be taken by not disposing of unmanaged waste into the sewage system, administering chlorine tablets according to dosage, and carrying out routine maintenance according to the Planned Maintenance System (PMS). Therefore, it is recommended that the crew understand and comply with MARPOL 73/78/97 regulations, operate and maintain the STP according to the manual, and conduct outreach regarding the types of waste that can be managed by the STP, along with strict sanctions for violators, so that engine performance remains optimal and marine pollution can be prevented.

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