Strategy for shipyard industrial waste management in controlling water and air pollution in ship repair

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Abstract. This study aims to determine environmental conditions, environmental management, environmental management strategies of PT. X in controlling environmental pollution. This research was conducted at PT.X Cilegon Banten shipyard in marine ship repair activities. This research uses a quantitative approach with cross-sectional. The research method in analyzing this research is a mixed method with survey methods and laboratory analysis. Manage strategies using questionnaires and interviews. Environmental quality data analysis uses predetermined quality standards and management strategies use SWOT analysis (Strength, Weakness, Opportunity and Threat). The results of environmental quality research of PT. X show the status of the environment that is heavily polluted to meet quality standards. The concentrations of heavy metals, namely Pb, Zn and Cu have exceeded the standard of quality at 3 stations and analysis of the quality of dust in the air in the shipyard area and around the shipyard occurs air pollution caused by the use of silica sand in the sandblasting process. Evaluation of the company's commitment in managing the work environment based on knowledge and attitudes is considered good by employees towards environmental management. The strategy carried out in environmental management at PT.X which was produced by researchers using the SWOT method, namely by increasing guidance and coordination in environmental management by forming an environmental division to reduce the impact of ship repair activities at the PT.X.

1. Introduction
Ships are a means of sea transportation that one day will experience damage to both the construction and other parts of the ship as a result of operations or other influences such as the environment or accidents. To maintain the condition of the ship optimally and the equipment contained in the ship still meets the requirements set by the bureau of class or classification used, it is necessary to periodically repair and maintain that involving the role of the shipyard industry which is engaged in repair, both in terms of repairs. and maintenance [1]. The increase in marine ship repair activities can lead to increased sea and air pollution. Water is an object that is very vulnerable to pollution other than air and soil. Contamination is something that is undesirable and in an amount that exceeds a predetermined limit [8].

Environmental pollution is the entry or inclusion of living things, substances, energy and or other components into the environment by human activities or natural processes, so that the quality of the environment drops to a certain level, which causes the environment to no longer function in accordance with its designation [10]. The shipyard industry can be divided into two major parts, namely new shipbuilding (ship building) and ship repair (ship repair). These two major parts always require an activity process that includes the calculation of materials, production equipment, labor, costs, infrastructure and the environment.
Shipyard activities have a risk of environmental pollution [3], especially during the ship repair process. Shipyard industrial waste is one of the industrial groups that produce hazardous and toxic waste. Because activities such as repairing ships produce hazardous and toxic waste, namely heavy metals from disposal of work materials [6]. Heavy metals in the waters that will drop and settle on the bottom of the water. Heavy metals cannot be destroyed and will accumulate in water to form deposits [11]. The disruptive effects of heavy metals on human health depend on which parts of the heavy metal content are protected in the body and the dose of exposure. Toxic effects caused by heavy metals are able to block the work of enzymes so that they can interfere with the body's metabolism, are mutagenic, cause allergies, teratogens, or are carcinogenic to humans or animals [12]. Heavy metals in general are essential for aquatic organisms for the growth and development of life, including in forming haemocyanins in the enzymatic system and blood in marine biota [4].

This results in organisms that forage at the bottom of the water have a great opportunity to be contaminated with these metals. Some certain marine biota such as shells can accumulate heavy metals in the body far exceeds those contained in the surrounding waters. Poisoning in consuming heavy metals can cause many things, such as shortening young red blood cells, decreased learning ability, and making children behave hyperactively. In addition, it can affect the body's organs, including the nervous system, reproduction, kidneys, endocrine system and heart [5]. As an effort by the company to eliminate / reduce the negative impacts arising from ship repair activities, the company is equipped with units in the processing of liquid waste, temporary toxic and hazardous material waste shelters, periodic monitoring carried out on site. Sources of raw materials are obtained from both local and imported, while the workforce is quite varied both in terms of education, gender and origin.

The quality of the PT.X shipyard waters from the measurement results (dissolved metals) of surface water quality (sea water), there are often findings regarding the higher level of heavy metal quality standards. Because according to [10] heavy metals that often pollute the environment and are dangerous, the main ones are copper (Cu), zinc (Zn) and lead (Pb). Aquatic environmental factors such as water pH can affect the toxicity (toxicity) of lead metal (Pb) in shipyard waters because a decrease in water pH will cause heavy metal toxicity to increase because heavy metals in water are able to form complex compounds that can settle on the bottom of the water [2].
2. Method

There are several ways to collect data in this study, including:

2.1. Survey Method
Field observations are needed to obtain data and information by looking directly at the condition of the PT.X Industrial area.

2.2. Standard Methods for Water Pollution Index
This method is used to see the level of water pollution based on test results in the laboratory.

\[
P_I = \sqrt{\frac{(C_I/L_q)_{42}^2 + (C_I/L_q)_{R}^2}{2}}
\]  

(1)

2.3. Calculation of Dust Content in the Air
This method is used to see the level of water pollution based on test results in the laboratory.

\[
V = \frac{(F1 + F2) \times t \times P_a \times 298}{2 \times T_a \times 101.3} \times 1000 \times V
\]

(2)

2.4. Management Strategy
The researcher used the SWOT method in determining the strategy using the matrix method, namely: the internal strategy factor matrix and the external strategy factor matrix. The internal and external strategy factor matrix is prepared in steps.

2.5. Location
The research location is in Puloampel village, Puloampel sub-district, Serang district, Banten Province, Indonesia. Serang Regency is one of eight regencies / cities in Banten Province, located on the western tip of the northern part of Java Island and is the main gateway connecting Sumatra Island with Java Island with a distance of ± 70 km from the city of Jakarta. The area is administratively 1,467.35 km\(^2\) which is divided into 28 (twenty-eight) sub-districts and 320 villages. Geographically, Serang Regency is located at coordinates 5°50' to 6° 21'. South latitude and 105°0' to 106°22' east longitude. The longest distance in a straight line from north to south is about 60 km and the longest distance from west to east is about 90 km.
2.6 Data collection and analysis

The concentration of Lead (Pb) at the sampling location in the area where the ship repair process was carried out to other sampling locations was different in the range of 0.08-0.18 mg/l. The lowest Pb concentration is found at station D (shrimp pond) right in front of the PT X shipyard heading to the high seas. Meanwhile, the highest concentration was found at station A (Slipway) because the main activity site for ship repair was 0.18 mg/l. The high concentration of lead at this station is thought to be a result of the process of the ship's hull, in this case ship repair, where the residues of production go directly into the waters and accumulate, this is in line that heavy metals have different properties that tend to accumulate in air. In the quality standard regulations that have been set, stations A, B, C and D exceed the maximum threshold of 0.05 mg/l.

The concentration of zeng ion (Zn) at the sampling location in the slipway area where the ship repair process to other sampling locations differs in the range of 0.02-1.9 mg/l. The standard deviation of each observation station can be seen in Figure 4.11. Station A and station B (Slipway) have concentrations of zinc heavily polluted due to direct contamination from ship washing activities, oil spills from ships during the repair process which are completely made of zinc, iron and steel, then for stations C and D are affected by ocean currents and waves that can cause contamination outside the PT.X shipyard. In the quality standard regulations that have been established, stations A, B, C and D exceed the maximum threshold of 0.01 mg/l. From the results of research on seawater in the area of ship repair work at PT.X shipyard, it was found that at stations A, B, and C exceeded the predetermined quality standards of 0.05 mg/l. The concentration of copper (Cu) values found ranged from 0.04 to 0.64 mg/l. The highest concentrations were detected at stations A and B (Slipway) due to direct contamination from ship repair activities caused by oil spills, ship washing and repair activities. Other. Station C and D are contaminated but not as big as stations A and B, because the stations are affected by ocean currents and waves so that the area outside the PT.X shipyard is contaminated.

In general, the ship repair process at the ship refinement stage at PT.X uses a grinding machine for welding results and uses the sandblasting process for the overall refining process. Sandblasting is the process of cleaning ship hulls and tritips, rust and other impurities that are carried out on the dock on dry ship conditions. Environmental conditions that are directly exposed to sand and dust can cause health problems where these materials can enter the human body through the respiratory tract. The results of the research at the location during the sandblasting process at station one obtained a value (94.73 mg/m³) and at station two (1.75 mg/m³). These results indicate that the process of sandblasting at PT.X exceeds the threshold according to the established regulations of 10 mg/m³ for...
the factory / industrial threshold value. Meanwhile, the dust exposure in public and office environments is (0.26 mg / m³).

Figure 3. Sandblasting process.

3. Results and discussion
The water conditions of stations A, B, C and D have varied results so it is interesting to use a pollution index based on the physical and chemical conditions of the waters. The value of the pollution index obtained from each station can be seen in Table 3.1.

Table 1. Water pollution index at all observation stations.

| No. | Station | Pollution Index | Status          |
|-----|---------|-----------------|-----------------|
| 1.  | A       | 15.82           | Heavy Contaminated |
| 2.  | B       | 14.26           | Heavy Contaminated |
| 3.  | C       | 3.78            | Light polluted |
| 4.  | D       | 1.29            | Comply with the regulations |

The results of the calculation of the chemical pollution index show that station A is in the heavily polluted category, station B is heavily polluted, station C is lightly polluted, while station D is still in the quality standard that has been determined in accordance with the Decree of the State Minister for the Environment Number 115 of 2013 concerning the determination of quality status water with the pollution index method where Plj > 10: heavily polluted, 1.0 <Plj ≤ 5.0 belongs to the lightly polluted group and 5.0 <Plj ≤ 10 is included in the medium polluted group. Where station A represents the ship repair area on the eastern slipway, station B represents the ship repair area on the western slipway, station C is a residential area and station D represents shrimp ponds belonging to local residents.

The results of the research on the air condition at the location during the sandblasting process at station one obtained a value (94.73 mg / m³) and at station two (1.75 mg / m³). These results indicate that the sandblasting process at PT.X exceeds the regulatory threshold set at 10 mg / m³ for the industrial factory threshold value. Meanwhile, exposure to dust in public and office environments is (0.26 mg / m³).

Table 2. General Environmental Air Test Results Report.

| No. | Parameter | Result | Quality standards | Unit | Method       |
|-----|-----------|--------|-------------------|------|--------------|
| 1.  | TSP       | 1.75   | 0.26              | Mg/m³| IKAS-5.7.6-EN |
Table 3. Work environment air test result report.

| No. | Parameter | Result | Quality standards | Unit | Method       |
|-----|-----------|--------|-------------------|------|--------------|
| 1.  | PM₁₀      | 94.73  | 10                | Mg/m³| Direct Reading|

Therefore it is necessary to control the process of ship refinement using the sandblasting method at PT.X because the dust can accumulate in the lungs for a long time which can disturb the health of field workers, employees and residents around the PT.X shipyard. short term and long term. The effect of sandblasting activities has happened before at PT.X, namely the existence of complaints/demonstrations from residents around the PT.X company due to air pollution around the shipyard which should be the company's basis for evaluating the refining process using the Sandblasting method.

3.1. Environmental aspect

Previous research has proven that these incidents occur in coastal environments not far from the ship industry, which are generally caused by ship repair activities. In general, several problems related to these facts and triggering factors for the decline in air and water quality can be seen from the condition of the repair industry activities. This condition was chosen because the main component that was not anticipated and handled would encourage damage and pollution to the coastal marine environment [9]. Basically, the management of coastal and marine areas is part of the environment, as previously thought by researchers who share the basic principles of environmental management, Which states that environmental management is an integrated effort to preserve the functions of the environment.

Based on the analysis, the poses of ship repair have an effect on the decline in seawater quality, namely Pb, Zn and Cu which is carried out by the water pollution index method and can prove that the waters around PT X are polluted. The concentrations of heavy metals, namely Pb, Zn and Cu, have exceeded the standard grade at 3 stations (A, B and C). Furthermore, for the results of the analysis of air quality in sandblasting activities, namely dust in the shipyard area and the area around the shipyard, the results of the analysis have stated that the implementation of air pollution is caused by the use of silica sand as the basic material for the sandblasting process where silica sand has dangerous metal elements.

3.2. Economic aspect

Used sand from sandblasting by firing silica sand grains with a high-pressure machine into the hull of the ship and other parts that require a blasting process, so far at PT.X it has only been left like that without any significant use. The sand used for sandblasting should be reused as the main material for sandblasting work or used as material for brick-making, paving and cone blocks. Sandblasting work on cleaning the hulls of medium-sized ships carrying out repairs on the dock of PT. X ranges from 5,000 m² - 10,000 m² per month and is taken an average of 7,000 m² per month, with details of the economic value as follows:

a. The use of sandblasting material for cleaning the surface of the hull is 1 m² of hull area required 40 - 50 kg of silica sand. The use of silica sand at PT.X is:
   - 7,000 m² x 50 kg = 350,000 kg/Month = 350 ton, or: 12 x 350 ton = 4,200 ton/Year.

b. In the process of minimizing waste at PT X, the hull cleaning process can save on the purchase cost of silica sand with an estimated total savings of Rp. 779,100,000, - /Year.

By implementing waste minimization in the sandblasting process at the shipyard, it is hoped that it can meet the shipyard economies of scale which will result in more side profits from the company. At the end of each year, the company will distribute every profit to employees so that the economic standard of the employees' household will be better. A good company economic condition will create jobs so that the surrounding community environment will improve.
3.3. Social aspect

The evaluation of PT.X commitment to environmental management that has been running is assessed based on the knowledge of PT.X employees on environmental management. Several questions were given to employees to measure employee knowledge about environmental management. The questions asked by researchers regarding understanding of environmental management policies in the company were analyzed using statistical tests for the results of their questions. The question material used by the researcher comes from the procedures that have been implemented in the company and is used as a reference for the work process at PT.X. Questions that will be asked regarding the understanding of the company's environmental policy, knowledge of waste generated from the ship repair process and how to handle it, standards for self-protection devices used in carrying out the ship repair process and handling of waste from ship repair in the company as the basis for researchers to determine the level of knowledge employees towards environmental management.

To measure employee knowledge, if it is true, it will be given a value of 1 and if the answer is wrong, it will be given a value of 0. After the results of the answers from all respondents are collected, it produces a final score of 52.7%, so it can be concluded that the company's commitment to environmental management is considered Good by the respondent. Knowledge of the environment can affect a person's attitude to the environment and environmental problems that are around him. With efforts to improve environmental education programs in schools. In principle, environmental management in the shipyard industry, including coastal environmental management, must be carried out in an integrated and comprehensive manner so that harmony and balance can be achieved between humans and the carrying capacity of the environment. Minimizing waste at PT.X is not yet included in the priority scale in all divisions. Meanwhile, good environmental management must be viewed systematically. The success of the environmental management system in the company to determine the environmental damage that will occur, this is not only the responsibility of employees, but all stakeholders this is in line with [7]. Effective management of a shipyard environment must view everything systemically, by reviewing and describing all its components as a whole (holistically) knowing and understanding all processes and relationships with one another.

Employee attitudes towards environmental management are measured by questions using a Likert scale. The questions given consisted of strongly agree, agree, doubt, disagree and strongly disagree. Researchers have 15 questions given to respondents. The total score obtained was 2873, based on the data collection method the researcher used the criteria was good.

| Table 4. Results of Employee Attitude Analysis |
|-----------------------------------------------|
| Total Score | 2873 |
| Maximum     | 3860 |
| Minimum     | 840  |
| Internal    | 840 – 1680 |
| Criteria    | 1681 - 2521 |
|            | 2522 – 3860 |
| Good        |       |
| Enough      |       |
| Bad         |       |

3.4. Sustainability status

Realizing an environmentally friendly shipyard requires strong efforts and determination from various parties related to shipyard work, especially in marine ship repair. The survival of marine life, coral reefs and other living things which will become a source of human food to sustain life. The balance of the ecosystem in the sea will produce diverse and abundant food sources for human life if managed sustainably. The current condition of the waters in the PT.X area has not met the quality standard requirements due to the ship repair process.
Based on the analysis score using the SWOT method, it can be concluded that PT.X is in the second quadrant of the SWOT quadrant matrix. The strategy proposed to make PT.X into a sustainable shipbuilding industry based on the results of the SWOT analysis is the SO Strategy, which is to collaborate with the community in managing production waste to be reused, by providing training related to shipyard industrial waste management to fill the void in the environmental division that has not yet formed at PT.X. WO strategy, namely striving to increase the effectiveness and mechanism of the company by setting targets in all departments with community empowerment assisted by the support of the central and local governments. ST's strategy is to increase guidance and coordination in environmental management by forming an environmental division to reduce the impact of ship repair activities so that PT X becomes an environmentally friendly shipyard as a selling point. WT strategy is to conduct regular monitoring to increase PT.X awareness of the importance of environmental management.

4. Conclusion
Based on the analysis of researchers about the quality of sea water conducted by the method of water pollution index it can be concluded that the waters around PT.X are polluted. Concentrations of heavy metals measured had exceeded the quality standard and were found at three stations. Furthermore, for the analysis of researchers regarding air quality, namely dust in the hull cleaning activity, the sandblasting process has the results of an analysis which states that air pollution has amounted to, due to the use of silica sand as a base material where silica sand contains metal elements that are harmful to health. The first priority that must be done from several strategies resulting from this research is to increase the effectiveness and coordination mechanism from the start of implementation, prevention and monitoring and evaluation in applying standard operating procedures, the second priority is prevention and control of pollution by implementing waste management that must be applied so that can get to the target of a sustainable ship repair & ship building industry.

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