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Analysis Corrosion Rate Carbon Steel by Mg Anode and $Na_2Cr_2O_7$ in Musi River Water Media

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ABSTRACT

This study aims to analyze and optimize the effect of Mg anode and sodium dichromate sacrificial protection on the corrosion rate of carbon steel in Musi River water media. The research involved carbon steel pipes (½ inch, 1 cm length) with an ID of 18.20 mm and OD of 18.80 mm. Four variables were tested: A (no corrosion prevention), B (Na2Cr2O7), C (Mg anode), and D (Na2Cr2O7 with Mg anode), each immersed in 150 ml of Musi River water for periods of 20, 30, 40, 50, and 60 days. Results showed the highest pH drop in variation A, where the initial pH of 6.87 decreased to 4.13 after 60 days. Variation A also showed the greatest increase in Fe concentration, rising from 1.47 mg/L to 4.89 mg/L, and turbidity from 80.8 NTU to 88.3 NTU after 60 days. Corrosion rate analysis indicated that carbon steel without corrosion prevention had the highest corrosion rate, reaching 0.0000025746 mpy after 60 days. In comparison, carbon steel with Na2Cr2O7 and Mg anode protection exhibited significantly lower corrosion rates. These findings highlight carbon steel pipes without corrosion protection experience higher degradation in Musi River water, while sodium dichromate and Mg anode treatments effectively reduce corrosion.

Keywords: carbon steel, corrosion prevention, anode Mg, sodium dichromate

INTRODUCTION

Musi River is a river that becomes the entry point of water from large and small rivers in both Bengkulu and South Sumatra. Musi River is about ± 720 kilometers long and passes through the city of Palembang (Masito et al., 2024) as well as other tributaries, has long played a major role in the lives of the people.

The role of the Musi River for the people around Palembang City, in addition to being a source of water used by the community for drinking water and bathing, is also a medium of transportation for both trade and delivery of goods, even as a source of livelihood for people who work as fishermen. Various industries such as textiles, petrochemicals, CPO, rubber, coal, and cement, use Musi River water for water treatment and disposal of waste, even the Pulokerto area and several other areas use Musi River water for agricultural activities. In line with that, the more industrial activities, transportation, agriculture, and domestic activities on the banks of the Musi River, the more the number of pollutants entering the Musi River increases.

Various industrial activities such as mining, plantation/agriculture, household activities, and natural activities produce waste that enters the Musi River, potentially damaging aquatic biota and health. This condition causes river pollution that affects the quality of its water. The growth of Palembang City along the river and the increase in population also increases activities in river waters, which has an impact on increasing waste that affects river water quality to cause river water pollution (Prasetyo, 2020)

The use of Musi River water as raw material for clean water treatment.

Therefore, corrosion protection becomes very important in infrastructure that comes into contact with river water, such as pipes, treatment units, and other structures. Protection can be done in various ways, including the use of corrosion-resistant materials, coatings, corrosion inhibitors, and sacrificial anodes. Various studies have been conducted in an effort to prevent corrosion including potassium iodide (KI) and water extract of merkubung sap (Macaranga gigan tea) against corrosion inhibition of soft steel in peat water media (Pradina et al., 2021), corrosion inhibition of soft steel in peat water media by electroplating method (Cholil et al., 2018), corrosion rate test using Moringa leaf inhibitor for hollow iron (Galvanic steel) in rainwater media (Yusuf et al., 2023), making cathodic protection simulation tools for steel piles in seawater zone (Solehudin et al., 2024)
Rusting or corrosion is the destruction of materials caused by environmental and surrounding influences. Physically, this rust is what can be seen clearly with the naked eye. Even in the world of industry and metallurgy, rust is the main cause of damage which results in changes in the mechanical properties of the material, causing considerable losses in terms of cost. Based on the above background, the authors are interested in analyzing the corrosion rate of carbon steel in the water treatment unit of Perumda Air Minum Tirta Randik with Mg and sodium dichromate anode protection in musi river water media: an experimental study approach in South Sumatra.

METHODOLOGY

Tools and Materials

The equipment used in this study are as follows: grinding, sandpaper, digital scales, pH meter, spectrophotometer, and turbidity meter.

Figure 1. Equipment and tools

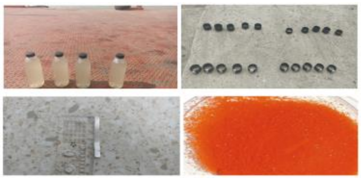

Figure 2. Analysis material

The materials used were carbon steel ½ inch length 1 cm with ID 18.20 mm and OD 18.80 mm, Mg anode, sodium dichromate inhibitor.

Research Procedures

- The collection of materials includes: carbon steel ½ inch length 1 cm with ID 18.20 mm and OD 18.80 mm, Mg sacrificial anode, 90% ethanol, sodium dichromate, musi river water, Sodium dichromate is made with a concentration of 200 ppm.
- Analysis of pH, Fe, and turbidity of Musi river water before immersion.
- The prepared corrosion testing containers used were labeled according to the test specimen. Then the container was filled with 150 ml of Musi River water.
- Test objects that have been cleaned and weighed, put into a container that has contained
    1. Prepare carbon steel pipes (½ inch, 1 cm length, ID 18.20 mm, OD 18.80 mm) for four variations: no protection, sodium dichromate coating, Mg anode, and combined Mg anode and sodium dichromate.
    2. Immerse each pipe in a container with 150 ml Musi River water for intervals of 20, 30, 40, 50, and 60 days.

3. Weigh each specimen to determine weight loss (Wf).

$$CR\ (mpy) = \frac{W\ x\ K}{D\ x\ As\ x\ T}$$

CR = Corrosion rate (mpy)
W = Weight Loss (gram)
K = Coupon correction factor (0.0017)
D = Specimen density (g/cm3)
As = Surface area (cm2)
T = Exposure time (hours)

4. Calculate corrosion rate and protection effectiveness then Measure pH, Fe, and turbidity levels of the water for each interval.

RESULT AND DISCUSSION

Table 1. Musi River Water Analysis Results Before and After Immersion

Parameters	Variable					
	BI	A	B	C	D	IT (day)
pH	6.87	4.40	5.15	5.20	6.10	20
		4.20	5.10	5.15	6.00	30
		4.18	5.07	5.13	5.98	40
		4.15	5.05	5.11	5.87	50
		4.13	5.00	5.08	5.55	60
Fe (mg/l)	1.47	2.21	2.10	2.06	1.82	20
		3.12	2.87	2.65	2.13	30
		3.45	3.21	2.89	2.27	40
		4.21	3.87	3.26	2.89	50
		4.89	4.22	3.77	3.12	60
Turbidity (NTU)	80.8	83.2	82.6	82.1	81.6	20
		86.8	85.4	85.2	84.2	30
		87.1	85.8	85.6	84.7	40
		87.9	86.3	85.9	85.2	50
		88.3	86.7	86.2	85.9	60

Notes:
BI: before immersion
A: without corrosion prevention
B: sodium dichromate plating corrosion prevention
C: corrosion prevention of Mg anodes
D: sodium dichromate and Mg anode corrosion prevention
IT: immersion time

Based on the results of analyzing the characteristics of Musi River water before and after immersion and analyzing the corrosion rate, can be seen in Table 1.

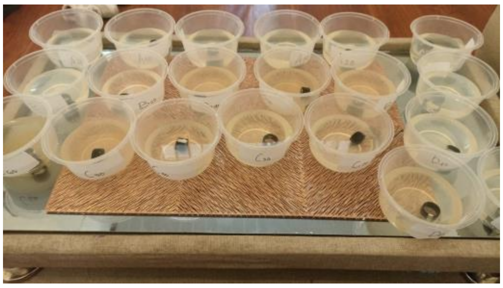

Figure 3. Carbon steel pipe immersion

The results of the analysis of Musi River water in Table 1 before and after soaking gave different results on the parameters of pH, Fe, and turbidity. The highest decrease in pH was in variation A (without corrosion prevention) where the pH before soaking amounted to 6.87 and dropped to 4.13 on the 60th day of soaking while for variation B (sodium dichromate) there was the highest decrease in pH on day 60 which was 5.00, then for variation C (Mg anode) the highest decrease in pH on day 60 was 5.08 and for variation D (sodium dichromate and Mg anode) there was the highest decrease on day 60 of 5.55. This is the same as other research (Irianty & Sembiring, 2012) that the longer the immersion, the pH of the water will decrease, and the corrosion rate will increase. The decrease in pH during longer immersion times in carbon steel pipes is due to the corrosion reaction that occurs between the metal and ions in the river water. When corrosion takes place, metal ions such as iron (Fe^{2+}) are released from the pipe surface into the solution, which produces by-products such as hydrogen ions (H^{+}) and acid. The buildup of H^{+} ions during this electrochemical reaction causes the water to become more acidic, thus lowering the pH over time.

There is an increase in Fe after soaking the carbon steel pipe. The highest increase in Fe is found in variation A (without corrosion prevention) where Fe before soaking amounted to 1.47 mg / l and rose to 4.89 mg / l on the 60th day of soaking, while for variation B (sodium dichromate) the highest increase in Fe on day 60 was 4.22 mg / l, then for variation C (Mg anode) the highest Fe increase on day 60 was 3.77 mg / l and for variation D (sodium dichromate and Mg anode) there was the highest increase on day 60 of 3.12 mg / l. This shows that the longer the immersion, the higher the Fe content in the water medium is caused by the corrosion of the carbon steel pipe. The increase in Fe concentration in the solution during longer immersion times is due to the corrosion process that takes place on the carbon steel surface. When metals corrode, iron (Fe) atoms dissolve into the water as Fe^{2+} or Fe^{3+} ions. Over time, more and more iron is released due to corrosion, so the concentration of Fe in the water increases. This process continues during immersion, causing the Fe value to become higher with increasing immersion duration.

Table 1 shows that there is an increase in turbidity after soaking the carbon steel pipe. The highest increase in turbidity was in variation A (without corrosion prevention) where Fe before immersion amounted to 80.8 NTU and rose to 88.3 NTU on the 60th day of immersion while for variation B (sodium dichromate) the highest increase in turbidity on day 60 was 86.7 NTU, then for variation C (Mg anode) the highest increase in turbidity on day 60 was 86.2 NTU and for variation D (sodium dichromate and Mg anode) the highest increase on day 60 was 85.9 NTU. This shows that the longer the immersion, the higher the turbidity levels in the water medium caused by the corrosion of the carbon steel pipe. The longer the immersion time, the turbidity value of the water will increase because corrosion causes iron particles and other corrosion by-products to escape from the metal surface into the water. Corrosion particles, such as iron oxide, are released and dispersed into the solution, causing the water to become more turbid. In addition, solid particles and small fragments of corrosion-damaged metal can also add to turbidity, especially in the absence of anticorrosion protection. Over time, the accumulation of these particles further increases turbidity.

Tests on the corrosion rate of carbon steel pipes with immersion in Musi River water media in variations of corrosion prevention and immersion duration give different results.

Table 2. Corrosion Rate Analysis Results

BI (Day)	Variable			
	A	B	C	D
20	0.0000007877	0.0000006461	0.0000004178	0.0000001895
30	0.0000018006	0.0000011918	0.0000008873	0.0000005829
40	0.0000020354	0.0000014646	0.0000010080	0.00000066554
50	0.0000023589	0.0000015370	0.0000011717	0.00000071508
60	0.0000025746	0.0000015852	0.0000012047	0.00000074811

Table 2 shows that after immersion of carbon steel pipes in Musi river water media with the highest corrosion rate or CR, namely in variation A (without corrosion prevention) with a 60-day immersion period of 0.0000025746 mpy, while for variation B with corrosion prevention using sodium dichromate coating, the highest corrosion rate or CR is obtained at a 60-day immersion of 0, 0000015852 mpy and for variation C with corrosion prevention using Mg anode, the highest corrosion rate or CR was obtained at 60 days immersion of 0.0000012047 then for variation D with corrosion prevention using sodium dichromate coating and Mg anode, the highest corrosion rate or CR was obtained at 60 days immersion of 0.00000074811 mpy.

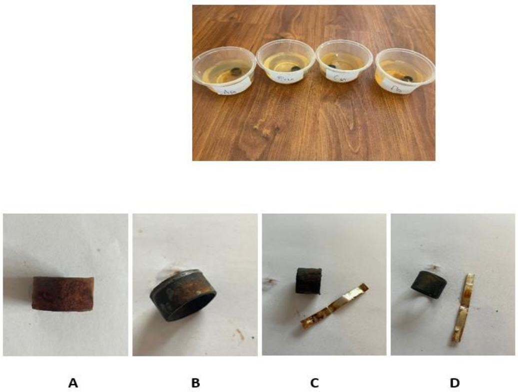

Figure 4. Carbon Steel Pipe Immersion for 60 Days

So it can be concluded that carbon steel pipes without using corrosion prevention will have the highest corrosion rate or CR compared to carbon steel pipes that use corrosion prevention such as using sodium dichromate coating or Mg anodes, and the best corrosion prevention in reducing the corrosion rate or CR is prevention using a combination of sodium dichromate coating and Mg anodes.

CONCLUSION

The study concludes that carbon steel pipes without corrosion prevention (variation A) showed the highest decrease in pH, increase in Fe, and turbidity after 60 days of immersion in Musi River water. The highest corrosion rate (0.0000025746 mpy) was also observed in this variation. In contrast, using a combination of sodium dichromate coating and Mg anode resulted in the lowest corrosion rate (0.0000001895 mpy) after 20 days. Therefore, the best method for reducing the corrosion rate is the combination of sodium dichromate coating and Mg anode.

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