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Estimation of MAC in Crumb Rubber Industrial Wastewater Treatment (WWTP) in Padang City

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Abstract. The research was conducted on 6 crumb rubber industries in Padang City to obtain MACs in the treatment of wastewater produced. All costs incurred by the crumb rubber industry to treat their wastewater represent the willingness to pay which is the basis for calculations for the equation model of the Marginal Abatement Cost (MAC). The data used in this research include the total costs incurred by the company in managing wastewater for the last fiveyears and concentration levels for BOD, COD, and TSS parameters. The crumb rubber industry studied has similarities in treating its wastewater, namely by using an activated sludge system. The value of reducing pollutant concentrations is 97%-99% after the wastewater is treated at the WWTPs of each company. The results of the analysis show that the marginal cost equation for the BOD parameter is MAC_BOD=-1913558462.293 + 1935477856.041 X - 255116140.649 X^2 + 8451011.993 X^3, for the COD parameter MAC_COD=-1459652908.169 + 429227907.049 X - 15172624.415 X^2 + 153022.692 X^3 and for the TSS parameter we get MAC_TSS=$e^{(21.280 + (-6.451/X))}$.

Keyword: industry, crumb rubber, MAC, pollutant parameter concentration, Padang.

1. Introduction

The Crumb rubber industry (processing) is one type of industry that is developing in Indonesia. Crumb rubber industry operations can have positive and negative impacts on the environment. The positive impacts are in the form of opening up employment opportunities, increasing business opportunities, and increasing people's income while the negative impacts include environmental pollution caused by factory operations such as odors, water pollution, air pollution, land contaminated with B3 waste, and high noise levels [1].

There are 6 (six) crumb rubber industries in Padang City, namely PT. PabrikKaret, PT. TelukLuas, PT. Batang Hari Barisan, PT. Kilang Lima Gunung, PT. Famili Raya, and PT. Abaisiat Raya. The wastewater produced has the characteristics of high levels of dirtiness, turbidity, and organic matter such as BOD reaching 320 mg/L, COD reaching 911 mg/L, and TSS reaching 618 mg/L. Crumb rubber operations use 30-40 m3 of water per ton of rubber for washing and cleaning [2]. The wastewater produced by each crumb rubber industry is treated with WWTP using the activated sludge method. This research was conducted to obtain the MAC of the crumb rubber industry in treating wastewater produced by the crumb rubber industry in Padang City. This research will be

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able to support Government Regulation No. 46/2017 on "Environmental Economic Instruments (IELH)" [3] which regulates the application of environmental taxes, levies, and subsidies so that the state can manage grant funds and other funds intended for environmental improvement and conservation.

2. Methods

The research was conducted on 6 (six) crumb rubber industries in Padang City, namely PT. PabrikKaret, PT. TelukLuas, PT. Batang Hari Barisan, PT. Kilang Lima Gunung, PT. Famili Raya, and PT. Abaisiat Raya. The location of the research carried out is shown in Fig 1 below.

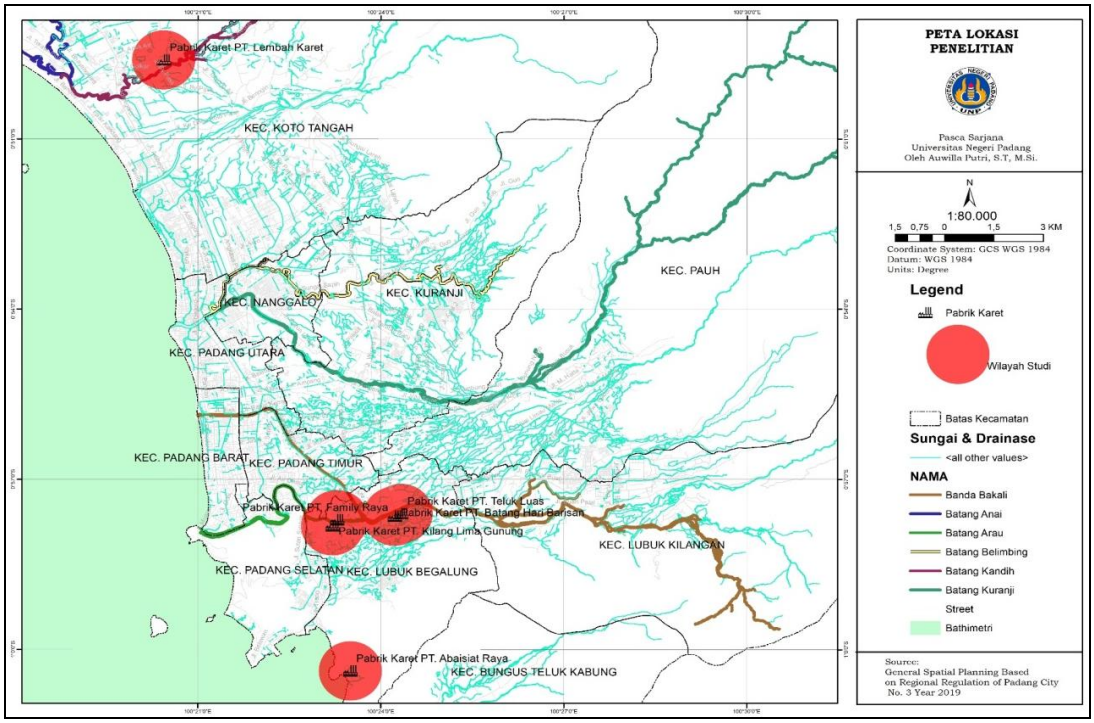

Fig 1. Map of research locations

The data obtained in this research were analyzed quantitatively. All costs incurred by the crumb rubber industry to treat their wastewater represent the willingness to pay/WTP (willingness to pay) value and become the basis for calculations for the model/equation of MAC. Data on cost components incurred by each industrial company crumb rubber in this study were obtained by using the total cost approach (total cost pricing).

In general, MAC is a derivative of TAC, as follows.

$$MAC = \frac{d\,TotalAbatementCost}{d\,WastewaterConcentration}$$

3. Results

Quality of Wastewater produced by the Crumb rubber Industry

In the rubber production process starting from the preparation of raw materials (rubber processing materials) to crumb rubber (SIR), sufficient water is required for the washing process, cleaning of rubber processing materials from contamination both at the chopping process stage and at the

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grinding process stage (creeper) and for Laboratory needs. The wastewater is then treated through WWTP using an activated sludge system. The following figure shows the quality of wastewater for BOD, COD and TSS parameters produced by the Crumb rubber industry in Padang City for the last 5 years.

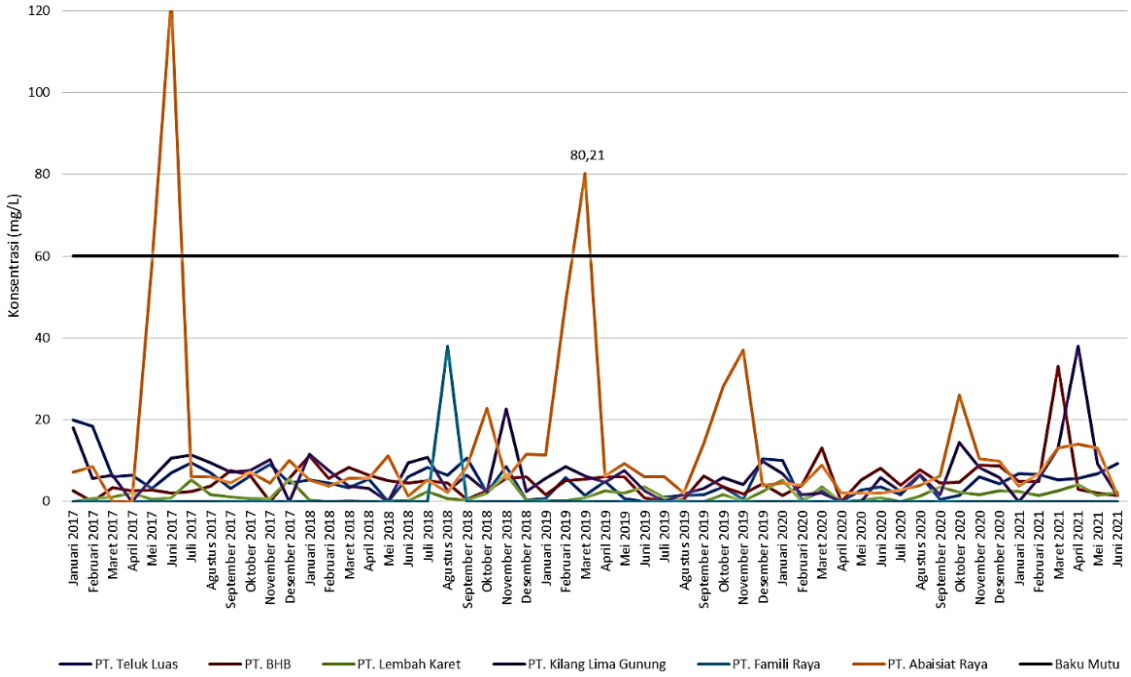

Fig 2. Concentration value of the Crumb rubber Industry BOD parameter in Padang City (WWTP Outlet) January 2017-June 2021

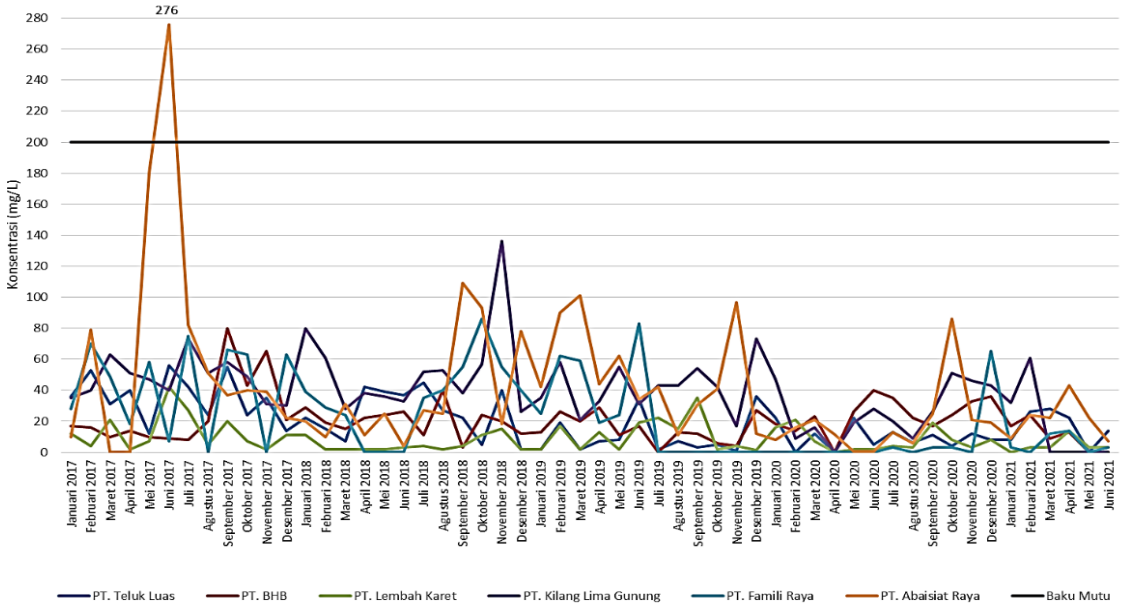

Fig 3. Concentration value of the Crumb rubber Industry COD parameter in Padang City (WWTP Outlet) January 2017-June 2021

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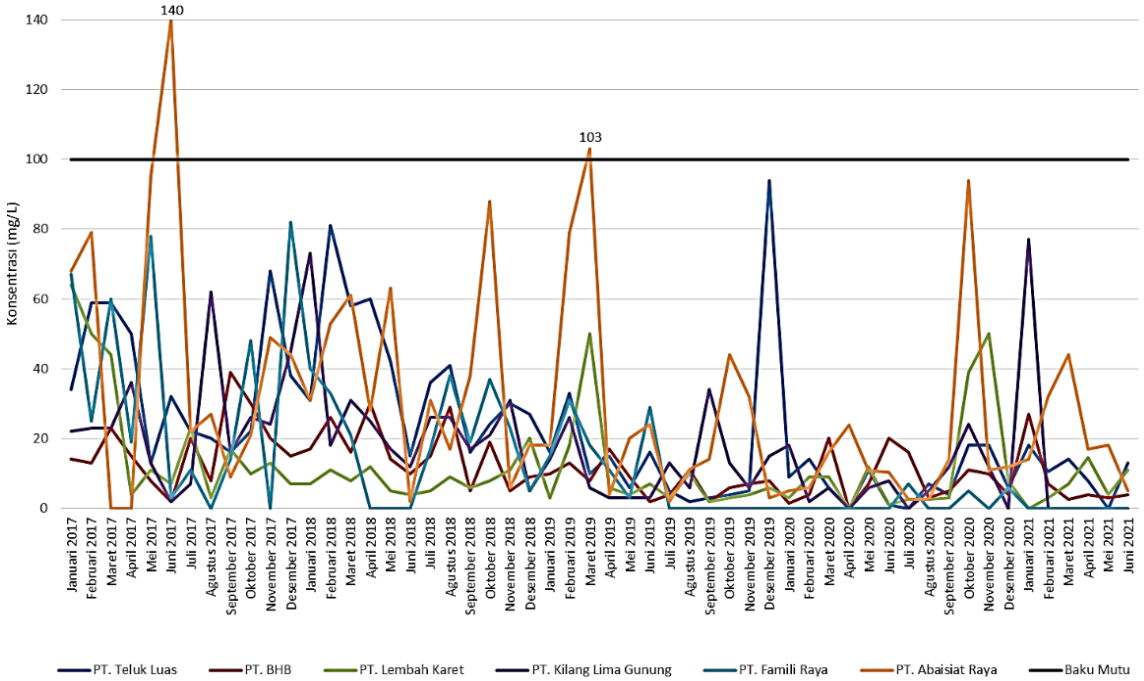

Fig 4. Concentration value of the Crumb rubberindustry TSS parameter in Padang City (WWTP Outlet) January 2017-June 2021

Total cost of WWTP issued

The Crumb rubber industry in Padang City makes efforts to treat the wastewater produced by treating the wastewater to the WWTP with an activated sludge system. This system was chosen because it can significantly reduce the concentration of pollutant parameters so that the wastewater due to the crumb industry operations does not damage the river. Evidence of poor compliance and wide variation infirm and industry-specific shadow prices provide compelling reasons for a comprehensive environmental redesign to control industrial water pollution in catchment areas [4, 5]. The costs incurred are.

- Prevention costs, which consist of evaluation and selection costs of raw material suppliers, staff training costs, environmental research costs, such as the creation of environmental documents, process, and product design costs to reduce wastewater generated, environmental management system development costs, recycling costs product rework and process costs to get ISO 14001 certificate.
- Detection costs, which consist of laboratory inspection fees for testing wastewater quality, product and process inspection costs (to be environmentally friendly), costs for purchasing daily wastewater test equipment such as litmus paper and instrument calibration, development costs for environmental performance measures, verification costs environmental performance of suppliers and the cost of measuring pollution levels.
- Internal failure costs, such as the cost of making WWTP, replacing damaged WWTP equipment, re-use of wastewater, labor costs for the WWTP section, both salaries and social security such as BPJS and insurance, maintenance and repair costs for WWTP, operating costs for WWTP such as PDAM

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water costs, electricity and fuel generators, costs for permits related to WWTP operations, costs for purchasing bacteria for WWTP operations and costs for purchasing chemicals for WWTP operations.

– External failure costs, which consist of environmental cleaning costs due to wastewater disposal, costs of repairing/normalizing the drainage of the sewerage, costs of settling personal accident claims (related to wastewater), costs of lost sales due to poor environmental reputation, usage costs inefficient raw materials and electricity, medical treatment costs due to accidents at WWTP operations, job losses due to wastewater pollution, groundwater and surface water tax costs, environmental CSR costs.

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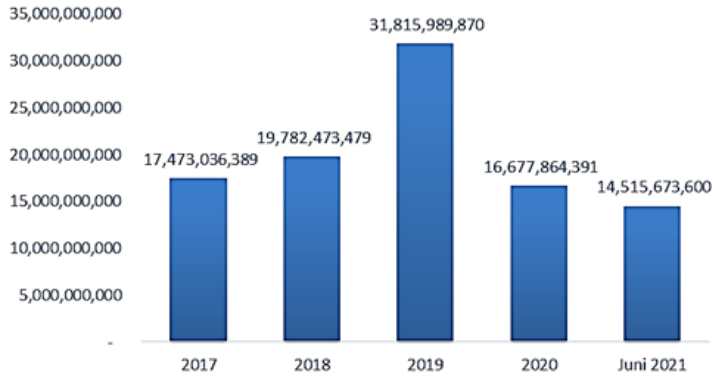

Fig 5. The total cost of WWTP issued by the Crumb rubber Industry in Padang City

MAC of crumb rubber industrial WWTP in Padang City

Determination of the MAC equation for wastewater from a rubber factory in Padang City is done by estimating the MAC value for each parameter (BOD, COD and TSS). The data used in this study include the total costs incurred by the company in managing wastewater every yearTACand the level of parameter concentration (BOD, COD, and TSS) (Table 1). The value of reducing the concentration of liquid waste shows the amount of pollution that the company managed to reduce after going through the WWTP process at each company's WWTP. It is intended that the wastewater discharged into the river meets the quality standards set by the government.

Table 1. Parameters'Concentration level and Total Cost of Crumb rubber industrial WWTP in Padang City

No	Name of Industry	BOD (mg/L)					COD (mg/L)				
		2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
1	PT. Teluk Luas	8.372	5.119	2.698	3.327	6.728	35.167	25.250	10.500	9.617	16.333
2	PT. BHB	3.305	5.516	3.524	5.886	8.233	26.083	20.417	14.850	24.000	10.500
3	PT. Lembah Karet	1.709	1.139	1.236	1.801	2.400	13.333	5.000	11.205	7.750	4.333

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4	PT. KLG	7.693	6.913	5.005	4.652	11.240	47.333	53.167	42.083	26.167	15.500
5	PT. Famili Raya	7.555	9.439	6.819	2.088	2.855	50.250	40.417	46.333	9.125	5.333
6	PT. Abaisiat Raya	19.602	7.369	21.117	6.903	8.683	68.000	37.583	50.543	18.935	21.167

Next :

No	Name of Industry	TSS (mg/L)					TOTAL COST (IDR)				
		2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
1	PT. Teluk Luas	36.083	38.417	17.417	7.833	10.583	1,882,601,866	1,565,569,267	1,530,090,214	1,207,405,175	659,669,254
2	PT. BHB	17.250	16.250	8.083	8.458	7.917	4,211,190,443	5,256,244,764	6,305,095,534	4,429,465,044	2,634,744,474
3	PT. Lembah Karet	21.083	8.833	9.667	11.583	6.583	139,400,000	287,950,000	257,863,900	283,703,000	156,583,100
4	PT. KLG	24.917	25.167	11.833	7.750	12.833	956,871,078	855,930,326	805,443,725	713,199,536	392,748,135
5	PT. Famili Raya	39.000	26.083	14.333	3.750	3.083	1,259,985,558	1,337,102,382	1,297,431,562	1,338,899,490	627,653,538
6	PT. Abaisiat Raya	46.167	36.333	29.525	17.325	21.667	286,469,250	588,440,000	5,712,070,000	366,259,950	2,786,438,300

Source: Research results in 2022.

The calculation results of the MAC equation and curve for each pollutant parameter The slope of the MAC curve produced by each parameter is negative, meaning that any reduction in the concentration of each parameter will increase the additional costs incurred by the company. For more details, the following Fig 6, 7, and 8 are the MAC average equation for each parameter tested.

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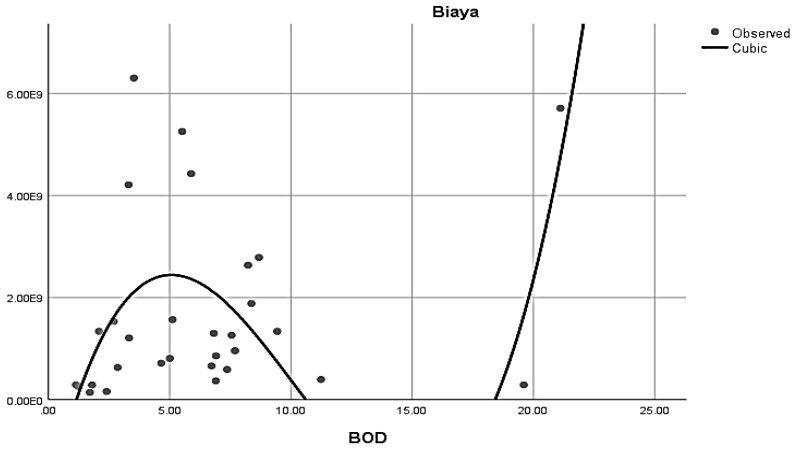
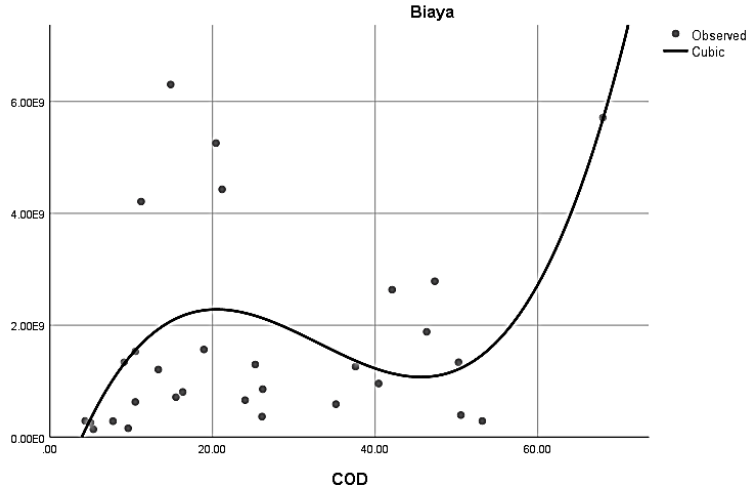


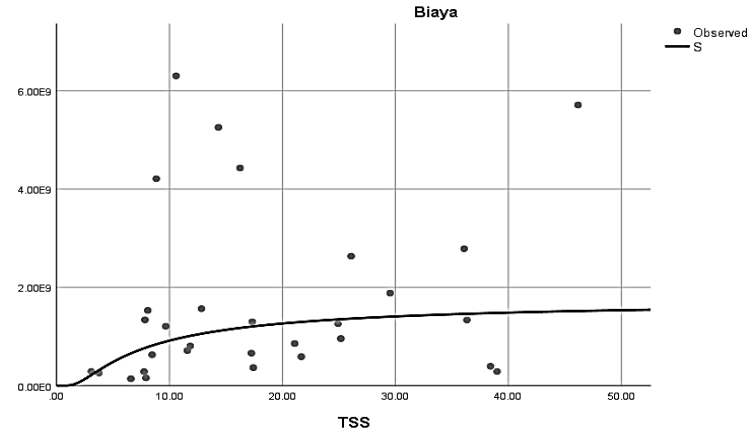
$$MAC_{BOD} = -1913558462.293 + 1935477856.041\,X - 255116140.649\,X^2 + 8451011.993\,X^3$$

Fig 6. MAC BOD, and the equation of the line



$$MAC_{COD} = -1459652908.169 + 429227907.049\,X - 15172624.415\,X^2 + 153022.692\,X^3$$

Fig 7. MAC COD, and the equation of the line



$$MAC_{TSS} = e^{(21.280 + (-6.451/X))}$$

Fig 8. MAC COD, and the equation of the line

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The MAC curve for each parameter has a negative slope value, meaning that the greater the reduction in the concentration of liquid waste, the greater the costs incurred by the company. The MAC curve for each parameter starts from the maximum pollutant level (inlet) which is the highest level of parameter concentration produced by the company before any efforts in the WWTP process. This means that no costs will be incurred by the company. Conversely, by reducing the concentration of each parameter, the greater the MAC issued by the company. Failure to address and include costs in existing waste facilities in decision-making could inadvertently lead to higher overall costs at the community level.

CONCLUSIONS

Based on the results of the study, it was concluded that marginal cost equation for incurred by the crumb rubber industry in Padang City for the BOD parameter is MAC_BOD= -1913558462.293 + 1935477856.041 X - 255116140.649 X^2 + 8451011.993 X^3, for the COD parameter we get equation MAC_COD=-1459652908.169 + 429227907.049 X - 15172624.415 X^2 + 153022.692 X^3 and for the TSS parameter we get MAC_TSS=$e^{[21.280 + (-6.451/X)]}$.

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