

DAFTAR PUSTAKA

- Allen, Christopher T., George S. Young, and Sue Ellen Haupt. 2007. "Improving Pollutant Source Characterization by Better Estimating Wind Direction with a Genetic Algorithm." *Atmospheric Environment* 41(11): 2283–89.
- Artana, Ketut Buda et al. 2014. "Enhancement On Methodology For Estimating Emission Distribution At Madura Strait By Integrating Automatic Identification System (Ais)" *3rd International Symposium of Maritime Sciences*.
- Ashari, A Y. 2018. "Pemodelan Dan Estimasi Emisi Gas Buang Terhadap Kualitas Udara Akibat Pertambahan Freight Dengan Metode Dinamika Sistem." Institut Teknologi Sepuluh Nopember. https://repository.its.ac.id/56318/%0Ahttps://repository.its.ac.id/56318/1/04211440000057-Undergraduates_Theses.pdf.
- Cebolla, Ortiz. 2022. *Quantifying Emissions in the European Maritime Sector*.
- Colls, Jeremy. 2002. *Air Pollution*.
- Fardiaz, Srikandi. 1992. *Polusi Air & Udara*. Yogyakarta: KANISIUS.
- Goodin, William R. 1981. "Development of a Second-Generation Mathematical Model For Urban Air Pollution- I. ModelFormulation." *Atmospheric Environment* 16: 679–96.
- Heeba, Norbert et al. 2011. "Parameters Affecting the Dioxin Formation in Diesel Particle Filters." https://nanoparticles.ch/archive/2011_Heeb_PR.pdf.
- Ignasius, Marinus, and Jawawuan Lamabelawa. 2019. "Perbandingan Interpolasidan Ekstrapolasi." 10(2): 974–82.
- Karan, Chopra. 2012. "A Guide to Ship Navigation Techniques." (Marine Insight).
- Kawashima, Shiro. 1995. "A Survey of Environmental Law and Policy in Japan A." *North Carolina Journal of International Law* 20(2).
- Khair, Magdi K, and W Addy Majewski Dieselnet. 2006. *Diesel Emissions and Their Control*. United States.
- Krause, Kai et al. 2021. "Estimation of Ship Emission Rates at a Major Shipping Lane by Long-Path DOAS Measurements." *Atmospheric Measurement Techniques* 14(8): 5791–5807.
- Liu, Pingjian, Eiichi Kobayashi, Teruo Ohsawa, and Mami Sakata. 2006. "Case Study on Health Assessments Related to a Modal Shift." *Journal of Marine Science and Technology*: 201–7.

- Pitana, Trika, Eiichi Kobayashi, and Nobukazu Wakabayashi. 2010. "Estimation of Exhaust Emissions of Marine Traffic Using Automatic Identification System Data (Case Study : Madura Strait Area , Indonesia)." (x): 0–5.
- Rahmawaty. 2002. "Dampak Pencemaran Udara Terhadap Tumbuhan."
- Saputra, Hanagia, Universitas Padjadjaran, Adi Maimun, and Jaswar Koto. 2013. "Estimation And Distribution Of Exhaust Ship Emission From Marine Traffic In The Straits Of Malacca And Singapore Using AIS Data." *The 8 th International Conference on Numerical Analysis in Engineering*.
- Supriyatin, Riya, Andrea Emma Pravitasari, and Didit Okta Pribadi. 2020. "Pemetaan Karakteristik Wilayah Urban Dan Rural Di Wilayah Bandung Raya Dengan Metode Spatial Clustering." *Jurnal Geografi* 12(02): 125.
- Trozzi C, and Vaccaro R. 1998. "Methodologies for Estimating Air Pollutant Emissions from Ships." *Proceeding of 22nd CIMAC International Congress on Combustion Engines* (December): 775–82.
- Trozzi, Carlo. 2011. "Emission Estimate Methodology for Maritime Navigation."
- Visscher, Alex De. 2014. *Air Dispersion Modelling*.

LAMPIRAN

Lampiran 1. Jumlah Kapal dalam Tabulasi per Bulan dari 2017 sampai 2021

Bulan	2017	2018	2019	2020	2021
Januari	220	235	231	230	240
Februari	234	242	239	199	234
Maret	228	247	240	201	221
April	209	220	236	190	231
Mei	202	248	230	200	229
Juni	228	197	247	194	210
Juli	219	232	234	190	239
Agustus	249	238	230	202	196
September	249	244	225	194	237
Oktober	271	237	225	219	237
November	235	237	210	229	209
Desember	252	235	231	219	220
Rata-rata	233	234	232	206	225

(Sumber: Kantor VTS Makassar)

Lampiran 2. Tabel Jumlah Emisi Gas Buang dari tahun 2017 sampai 2021 pada setiap jenis polutan dan Jumlah Bahan Bakar

Bulan	Jumlah Emisi Gas Buang NO ₂ (ton)				
	2017	2018	2019	2020	2021
Januari	53,09715	71,56201	94,31744	100,0468	75,6639
Februari	64,17645	94,70721	76,40832	50,53944	88,58299
Maret	90,5621	87,4896	102,3293	49,7331	70,78591
April	71,76302	104,7825	70,84761	60,37651	81,51046
Mei	70,3189	78,88731	79,45302	53,44832	70,3201
Juni	84,49365	93,43148	98,02719	67,42117	63,30578
Juli	65,32705	58,21982	62,62493	57,29301	91,45881
Agustus	107,8906	106,6634	72,30394	69,36727	90,26794
September	73,6728	93,27619	87,69635	47,24518	89,57245
Oktober	130,4993	86,79585	80,30767	70,4891	99,2309
November	111,7023	122,3165	60,44329	64,5344	62,23713
Desember	118,4992	76,49921	99,39856	73,74012	85,48913
Jumlah	1042,003	1074,631	984,1577	764,2344	968,4255

Bulan	Jumlah Emisi Gas Buang SO ₂ (ton)				
	2017	2018	2019	2020	2021
Januari	2,241	3,023	3,981	4,227	3,195
Februari	2,708	3,996	3,231	2,116	3,741
Maret	3,821	3,696	4,319	2,091	2,988
April	3,029	4,425	2,990	2,548	3,441
Mei	2,968	3,332	3,359	2,176	2,972
Juni	3,566	3,943	4,137	2,358	2,671
Juli	2,757	2,459	2,643	2,442	3,864
Agustus	4,555	4,501	3,058	2,941	3,811
September	3,111	3,936	3,703	2,012	3,782
Oktober	5,509	3,663	3,391	2,991	4,191
November	4,715	5,161	2,560	2,716	2,627
Desember	5,000	3,229	4,198	3,089	3,609
Jumlah	43,982	45,365	41,571	31,706	40,892

Bulan	Jumlah Emisi Gas Buang PM _{2,5} (ton)				
	2017	2018	2019	2020	2021
Januari	1,169	1,576	2,075	2,199	1,665
Februari	1,411	2,086	1,680	1,111	1,950
Maret	1,994	1,926	2,253	1,095	1,557
April	1,580	2,306	1,559	1,329	1,794
Mei	1,548	1,737	1,749	1,179	1,549
Juni	1,860	2,057	2,159	1,483	1,392
Juli	1,438	1,282	1,378	1,261	2,013

Agustus	2,376	2,345	1,593	1,527	1,985
September	1,622	2,053	1,929	1,040	1,972
Oktober	2,873	1,911	1,768	1,553	2,184
November	2,459	2,693	1,331	1,421	1,370
Desember	2,609	1,684	2,189	1,623	1,880
Jumlah	22,940	23,655	21,663	16,821	21,312

Bulan	Jumlah Emisi Gas Buang PM ₁₀ (ton)				
	2017	2018	2019	2020	2021
Januari	1,169	1,576	2,075	2,199	1,665
Februari	1,411	2,086	1,680	1,111	1,950
Maret	1,994	1,926	2,253	1,095	1,557
April	1,580	2,306	1,559	1,329	1,794
Mei	1,548	1,737	1,749	1,179	1,549
Juni	1,860	2,057	2,159	1,483	1,392
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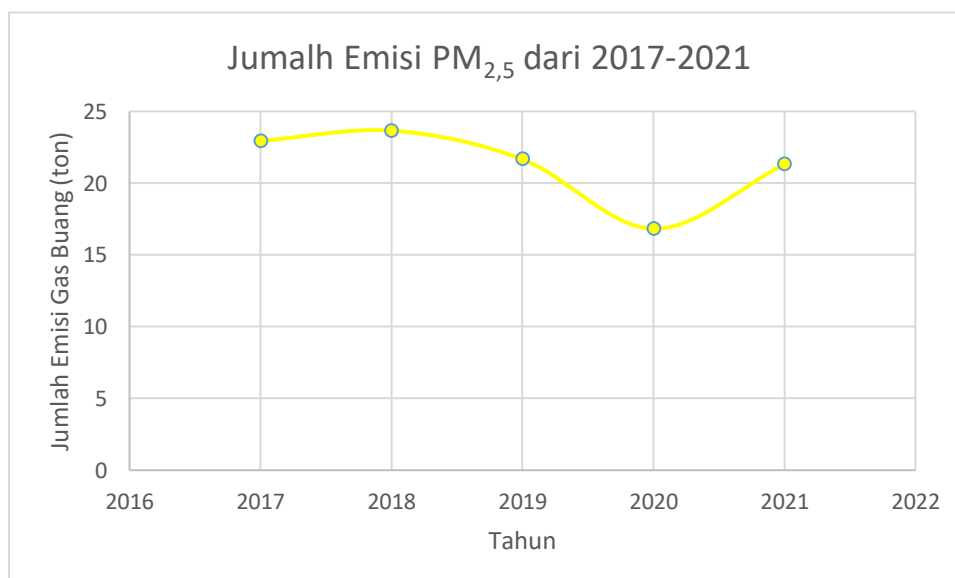
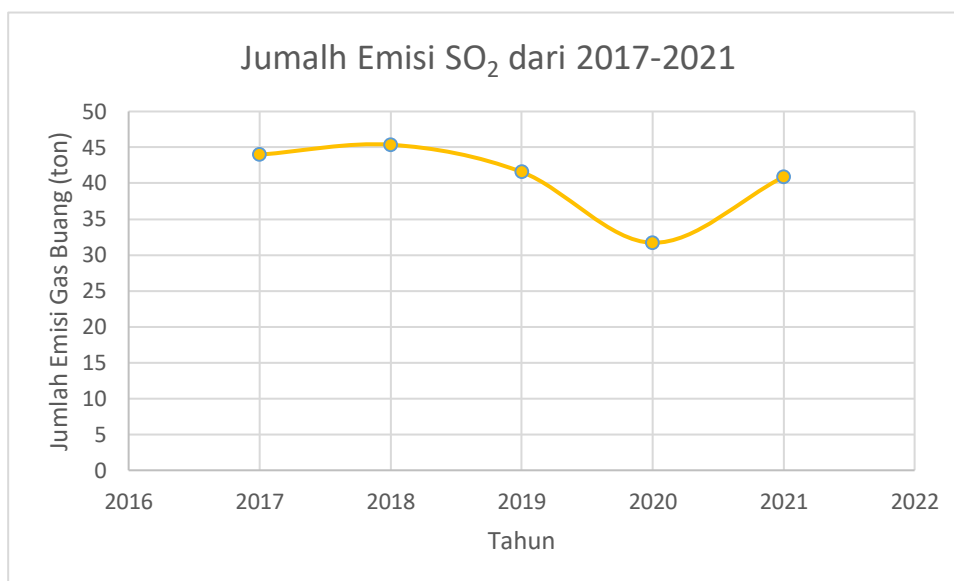
Bulan	Jumlah Emisi Gas Buang CO (ton)				
	2017	2018	2019	2020	2021
Januari	4,384	5,907	7,785	8,259	6,245
Februari	5,298	7,819	6,307	4,172	7,312
Maret	7,477	7,224	8,449	4,105	5,842
April	5,926	8,652	5,849	4,984	6,728
Mei	5,803	6,514	6,558	4,413	5,805
Juni	6,973	7,714	8,092	5,565	5,225
Juli	5,394	4,806	5,170	4,730	7,550
Agustus	8,909	8,806	5,967	5,727	7,451
September	6,083	7,701	7,236	3,900	7,394
Oktober	10,775	7,166	6,628	5,818	8,189
November	9,223	10,097	4,988	5,327	5,137
Desember	9,784	6,316	8,205	6,087	7,056
Jumlah	86,029	88,721	81,234	63,087	79,935

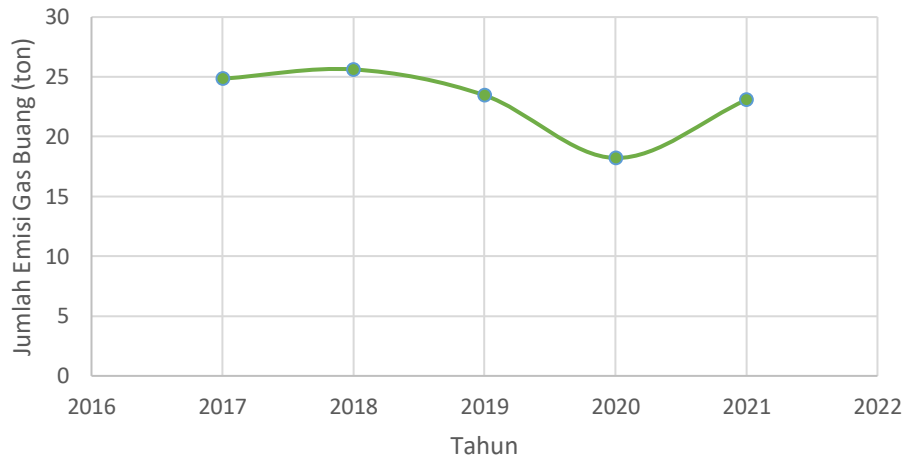
Bulan	Jumlah Emisi Gas Buang CO ₂ (ton/bulan)				
	2017	2018	2019	2020	2021
Januari	212,719	286,694	377,856	400,808	303,126
Februari	257,104	379,418	306,107	202,471	354,881

Maret	362,811	350,503	409,953	199,241	283,583
April	287,496	419,780	283,829	241,879	326,546
Mei	281,711	316,039	318,304	214,124	281,716
Juni	338,498	374,305	392,715	270,101	253,614
Juli	261,715	233,242	250,889	229,528	366,404
Agustus	432,230	427,314	289,662	277,897	361,629
September	295,146	373,681	351,326	189,271	358,842
Oktober	522,809	347,724	321,730	282,394	397,540
November	447,502	490,026	242,148	258,537	249,334
Desember	474,735	306,474	398,212	295,418	342,488
Jumlah	4174,477	4305,199	3942,731	3061,667	3879,702

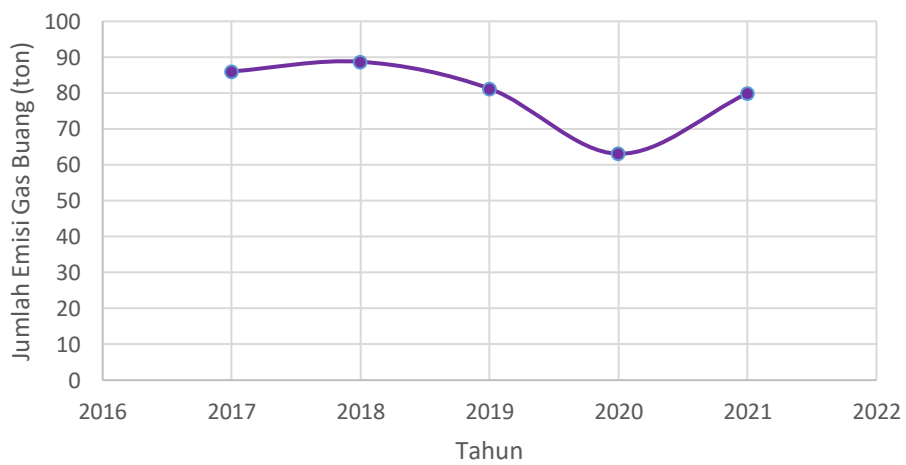
Bulan	Jumlah Bahan Bakar (ton)				
	2017	2018	2019	2020	2021
Januari	1736,481	2340,357	3084,537	3271,899	2474,494
Februari	2098,811	3097,287	2498,835	1652,822	2896,99
Maret	2961,726	2861,249	3346,554	1626,455	2314,964
April	2346,909	3426,773	2316,968	1974,52	2665,68
Mei	2299,685	2579,908	2598,4	1747,948	2299,719
Juni	2763,247	3055,552	3205,837	2204,905	2070,322
Juli	2136,448	1904,017	2048,074	1873,695	2991,051
Agustus	3528,406	3488,278	2364,591	2268,545	2952,075
September	2409,354	3050,458	2867,967	1545,073	2929,321
Oktober	4267,828	2838,562	2626,364	2305,253	3245,223
November	3653,079	4000,21	1976,716	2110,504	2035,38
Desember	3875,386	2501,826	3250,713	2411,577	2795,82
Jumlah	34077,36	35144,48	32185,56	24993,2	31671,04

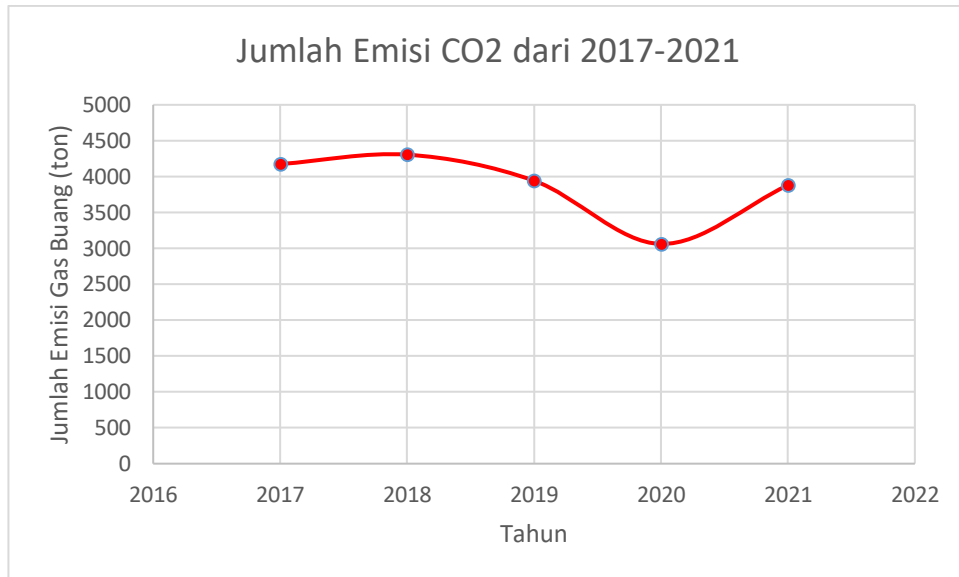
Lampiran 3. Grafik Jumlah Emisi Gas Buang untuk jenis polutan SO₂; PM_{2,5}; PM₁₀; CO; dan CO₂



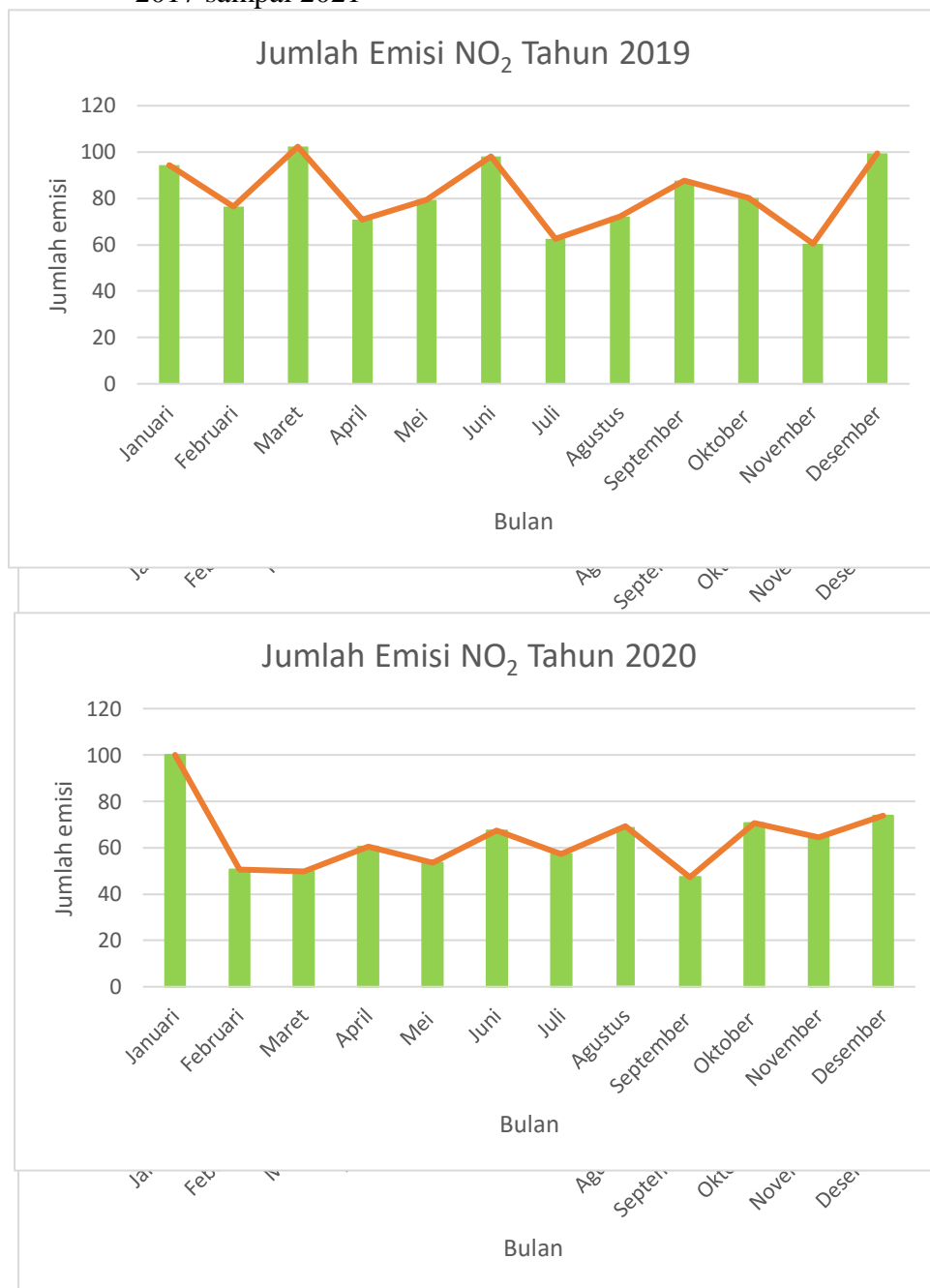
Jumlah Emisi PM₁₀ dari 2017-2021

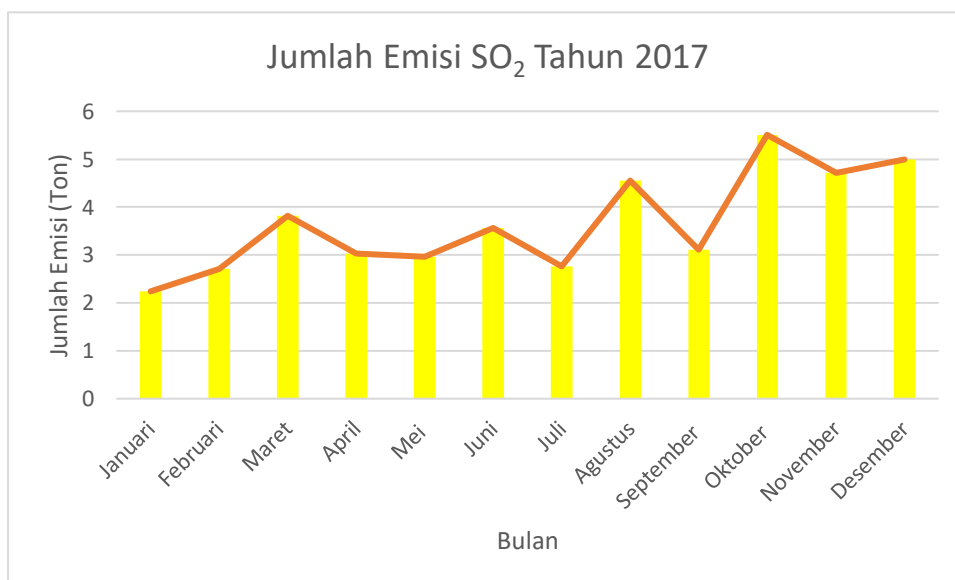
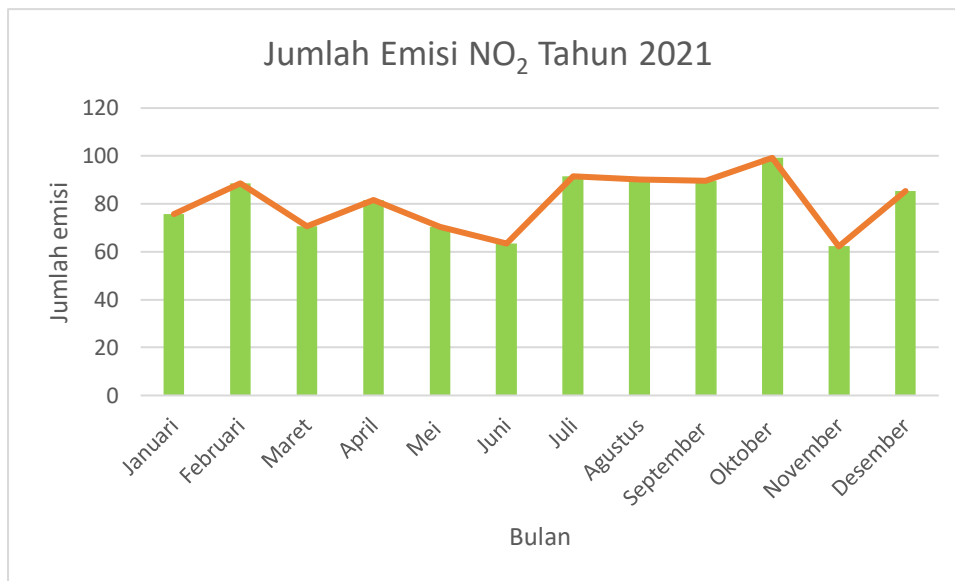
Jumlah Emisi CO dari 2017-2021

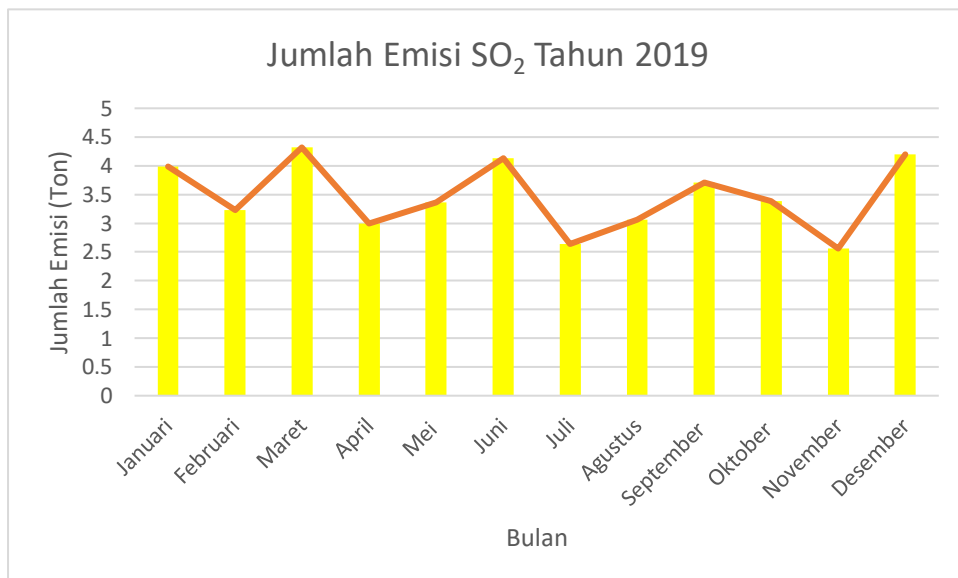
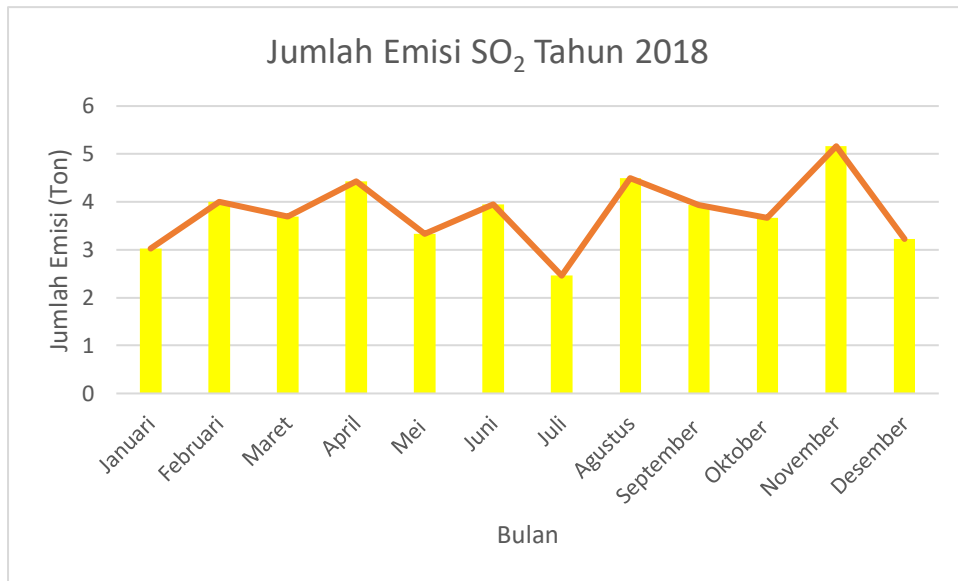


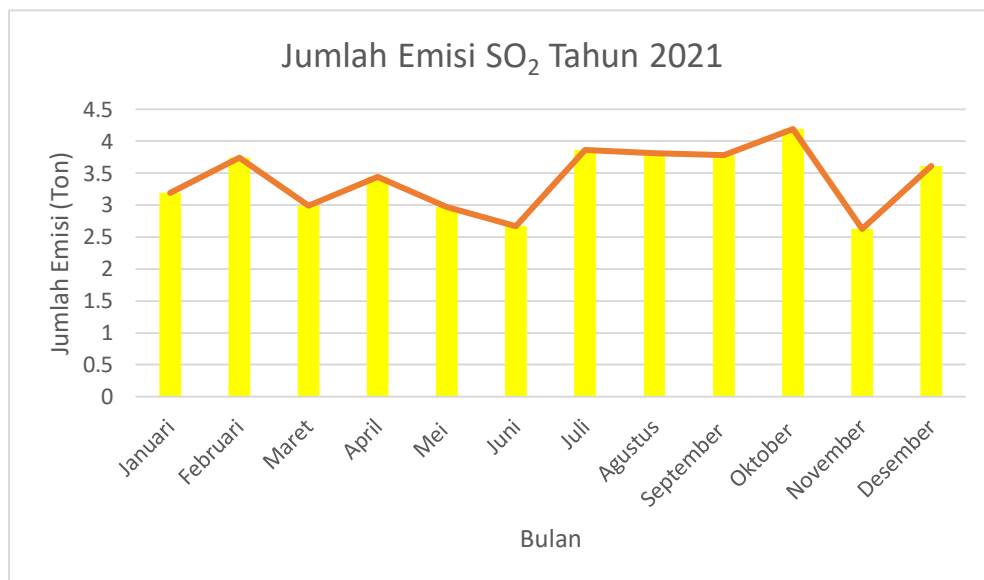
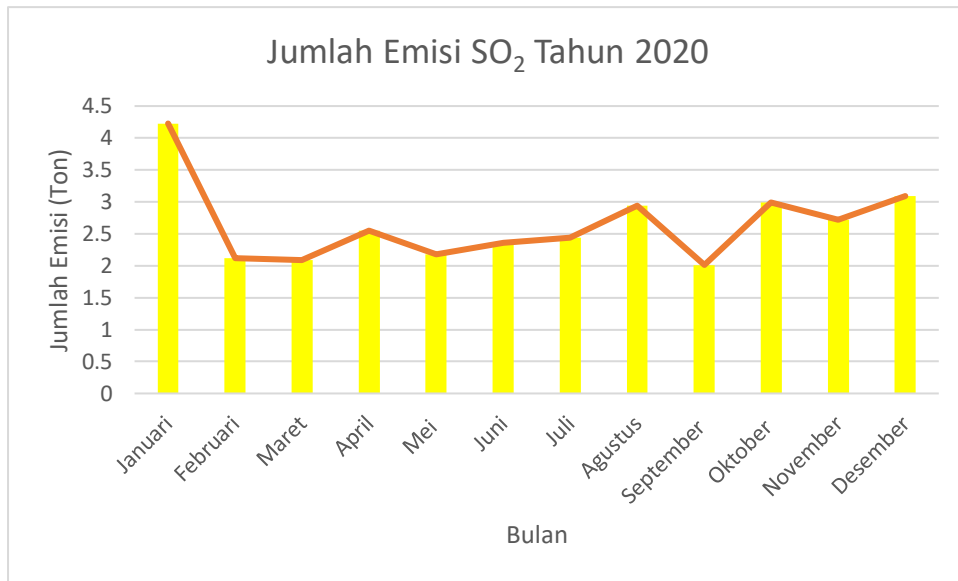


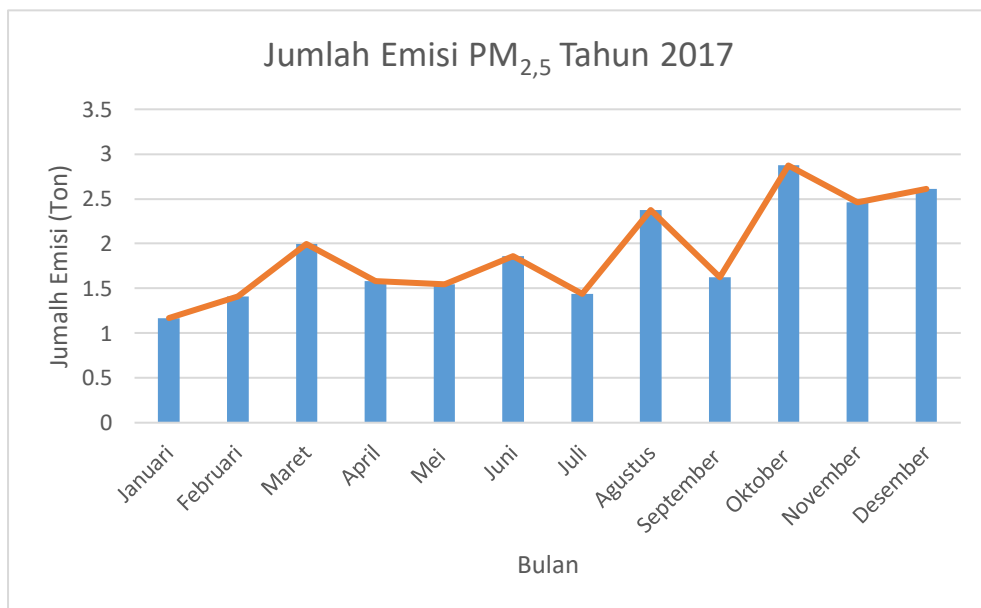
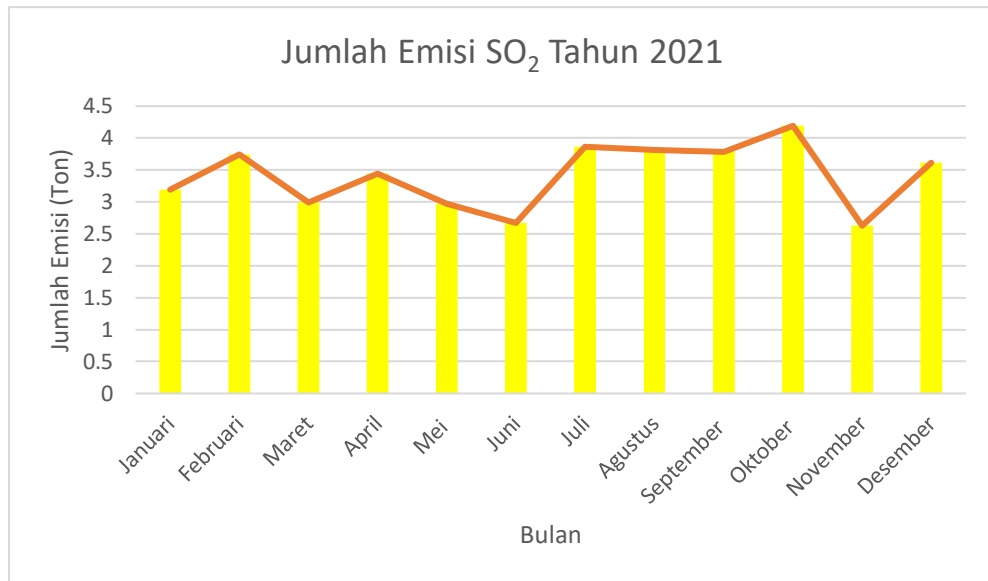
Lampiran 4. Grafik Jumlah Emisi Gas Buang Kapal Tabulasi Per Bulan dari tahun 2017 sampai 2021

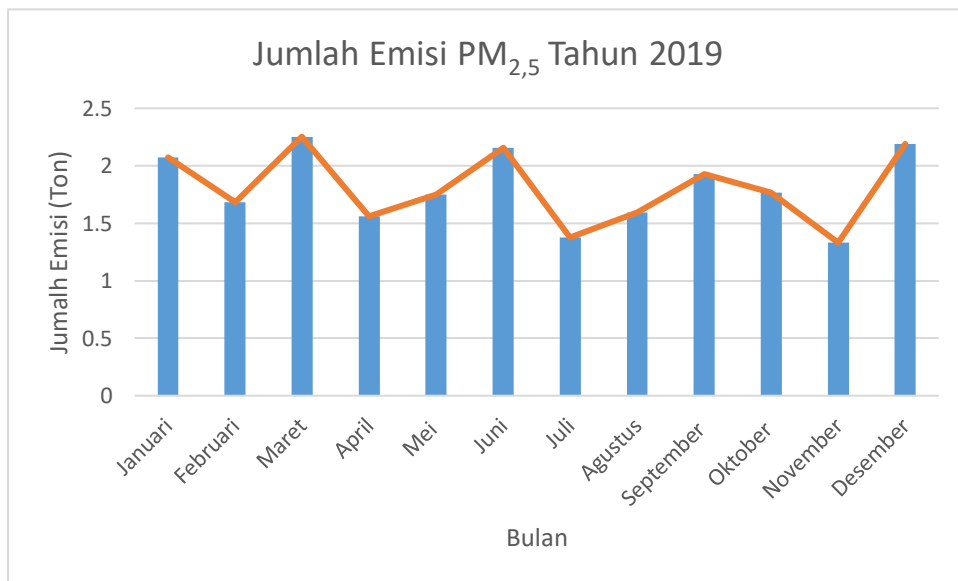
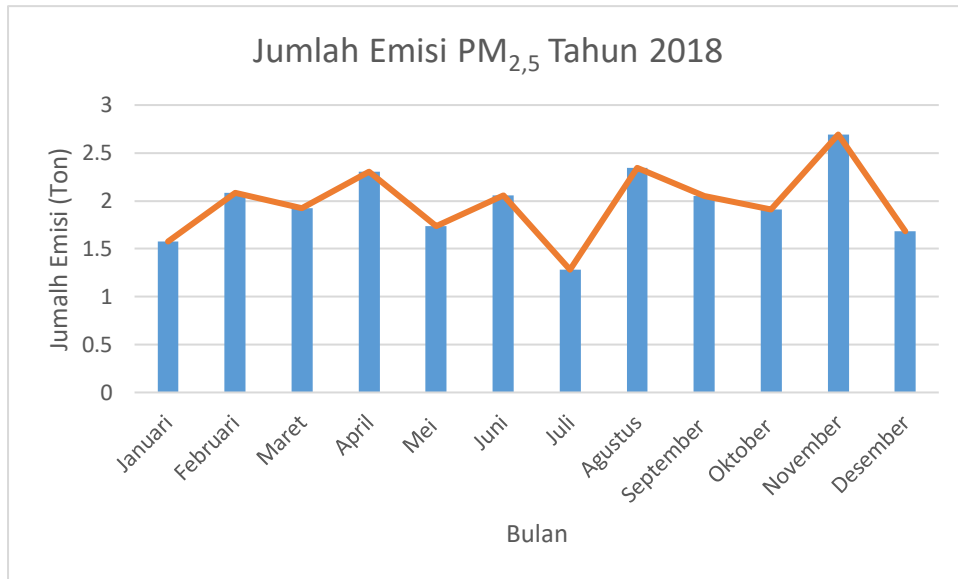


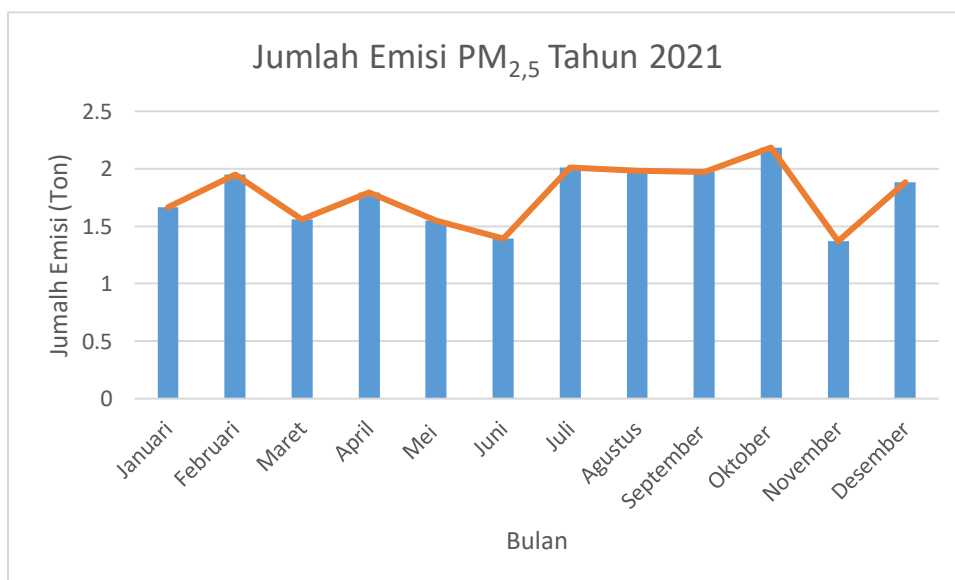
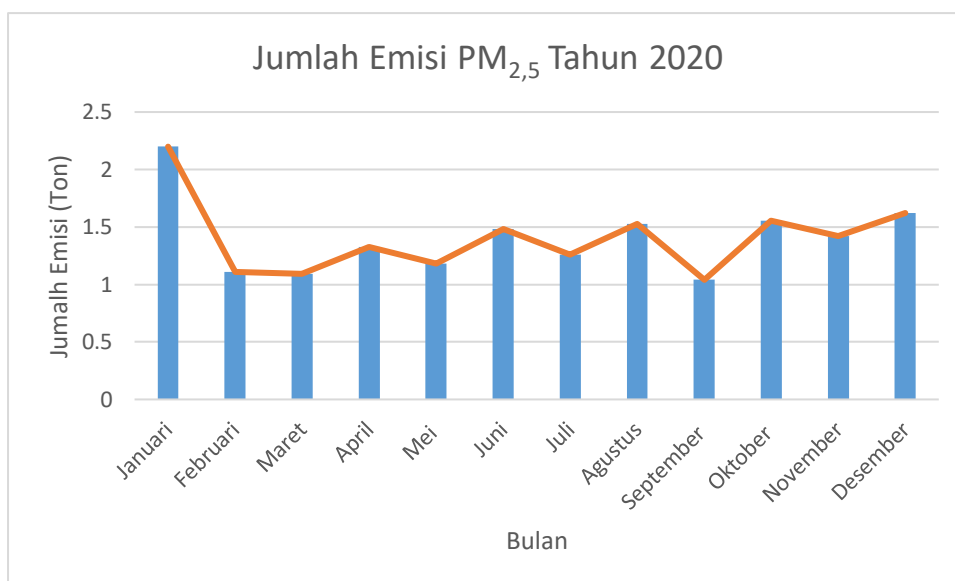


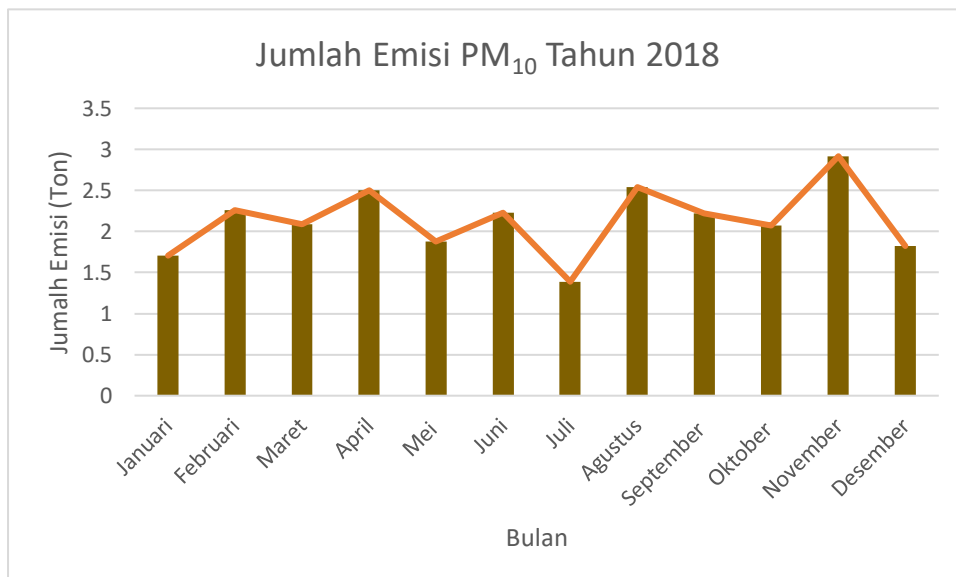
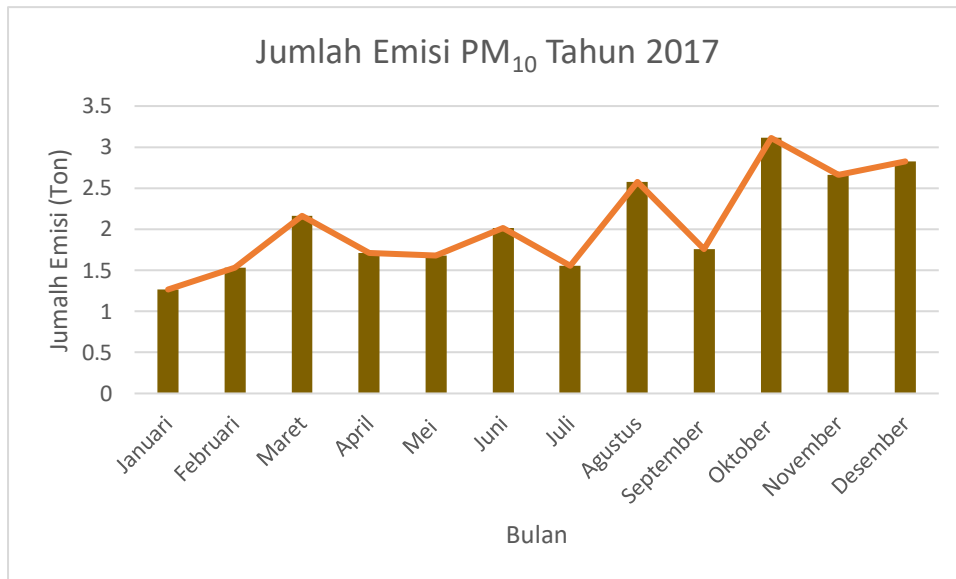


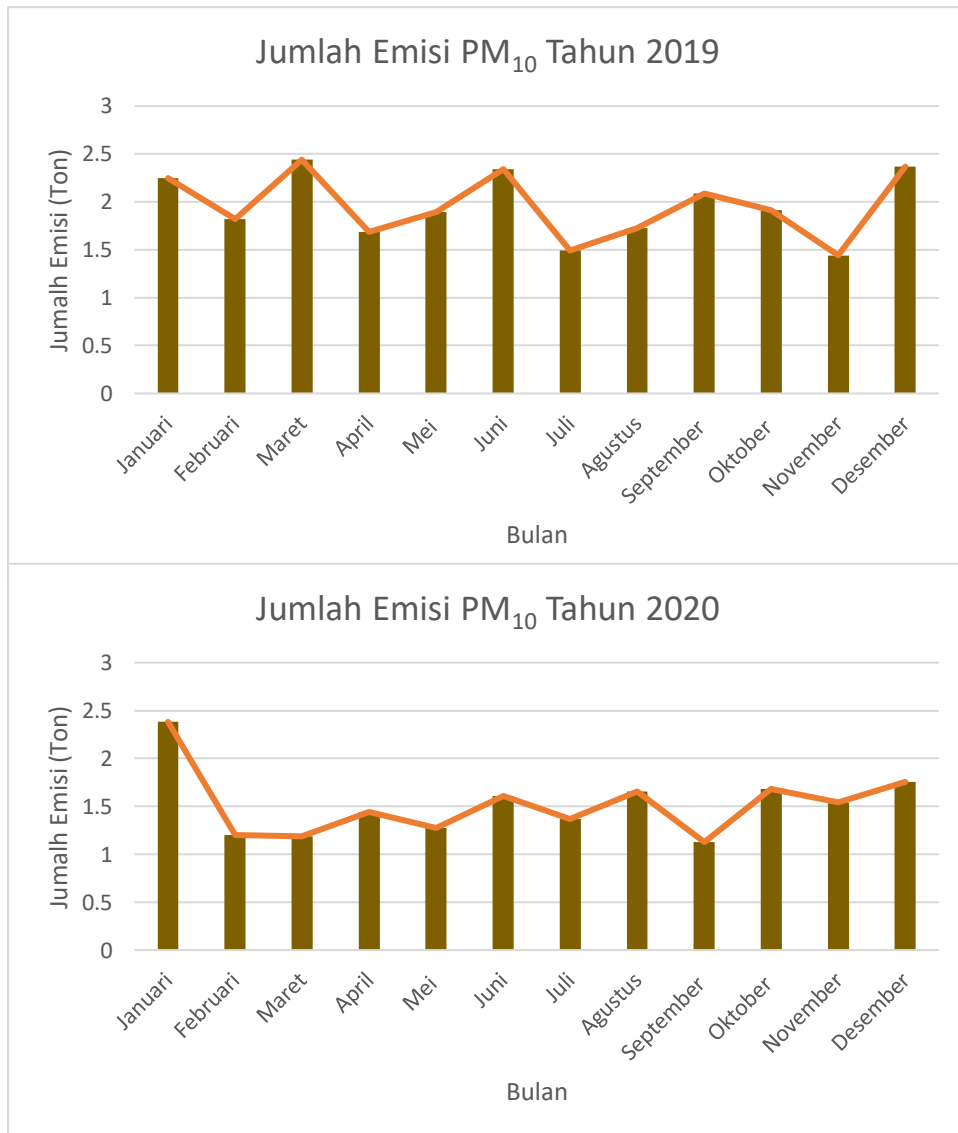


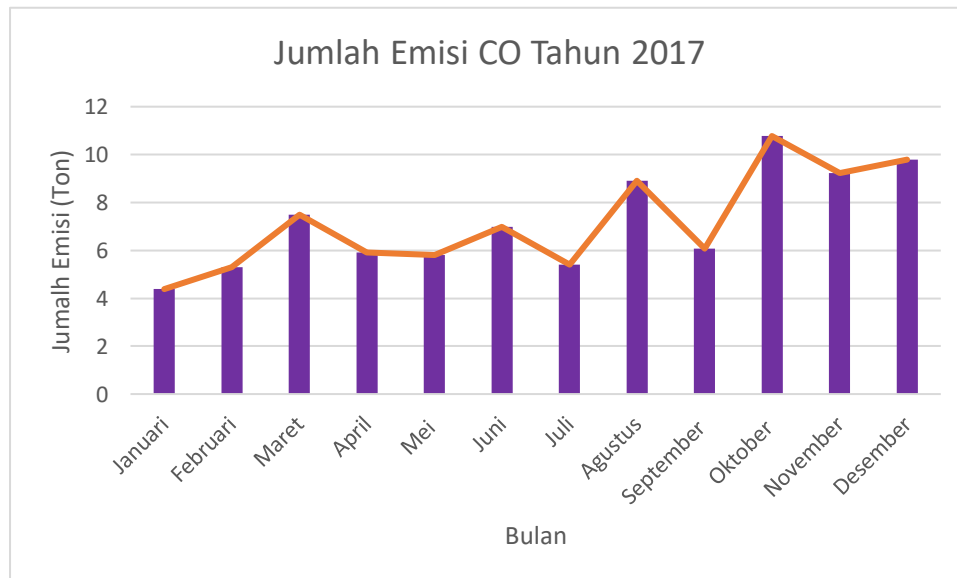
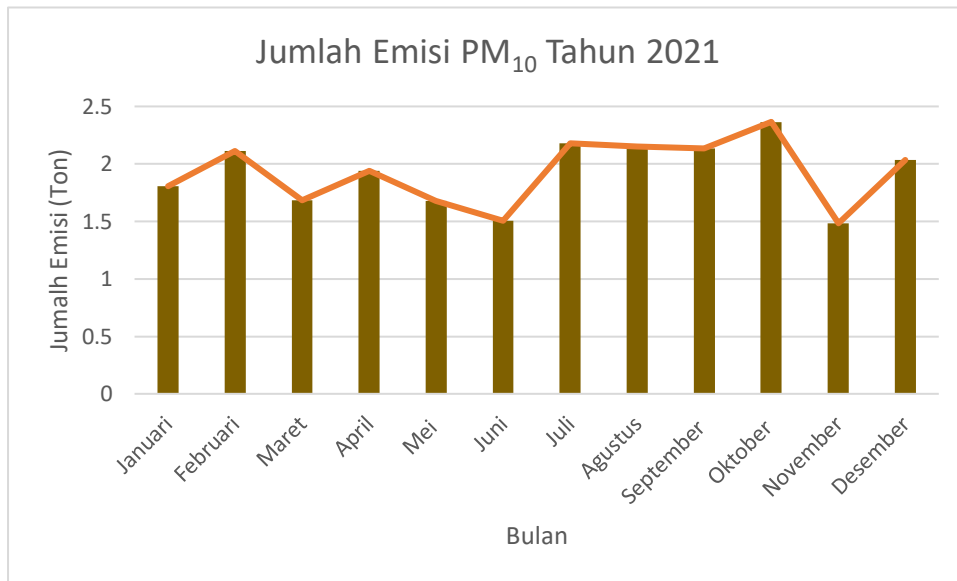


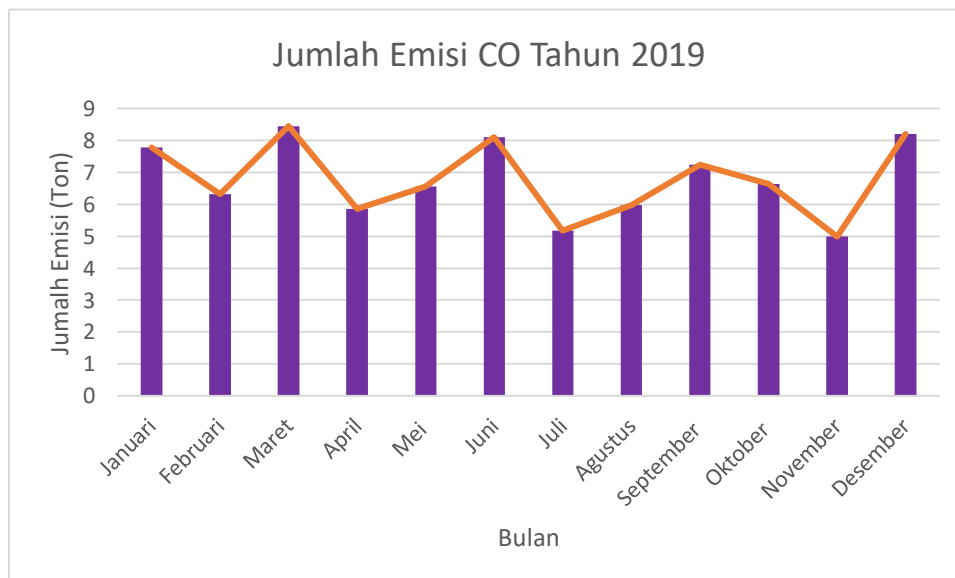
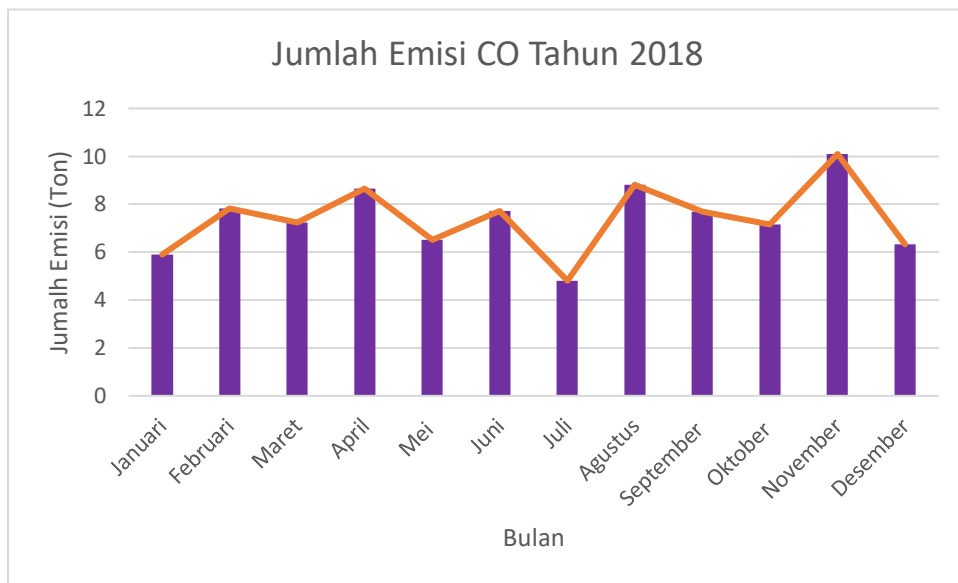


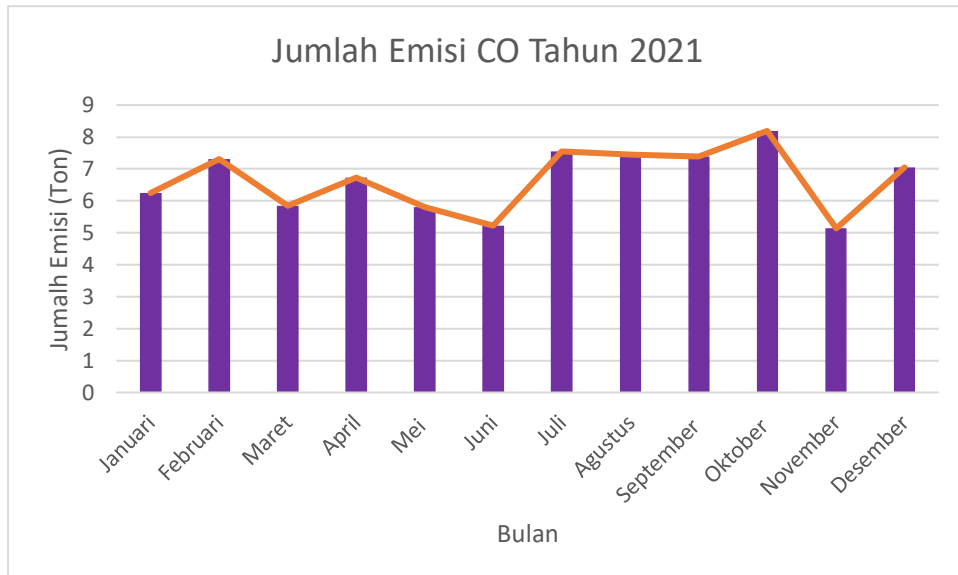
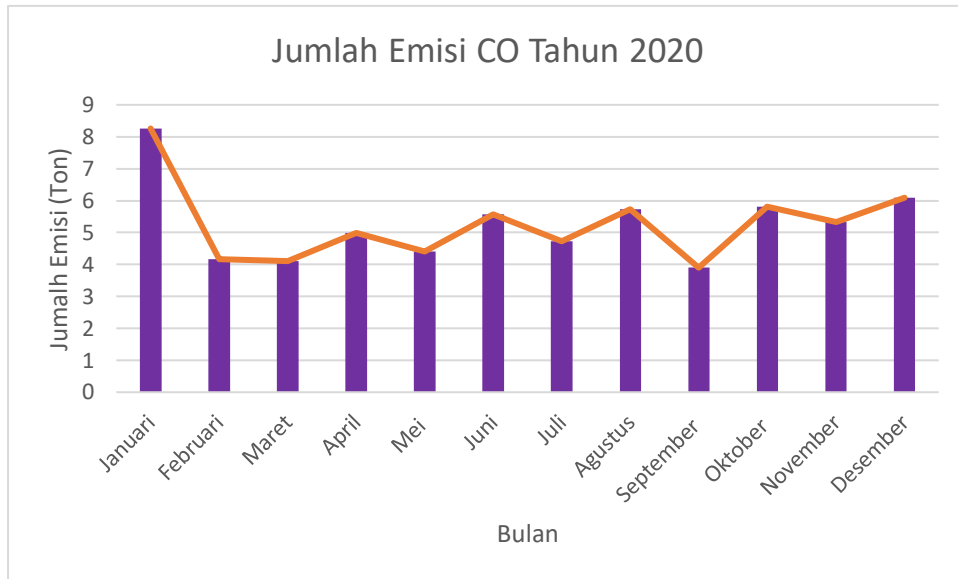


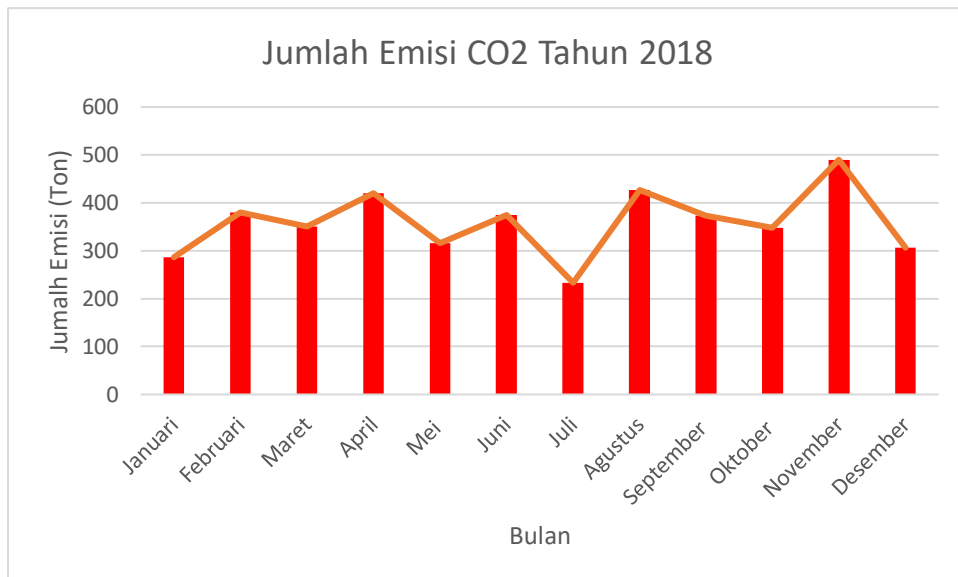
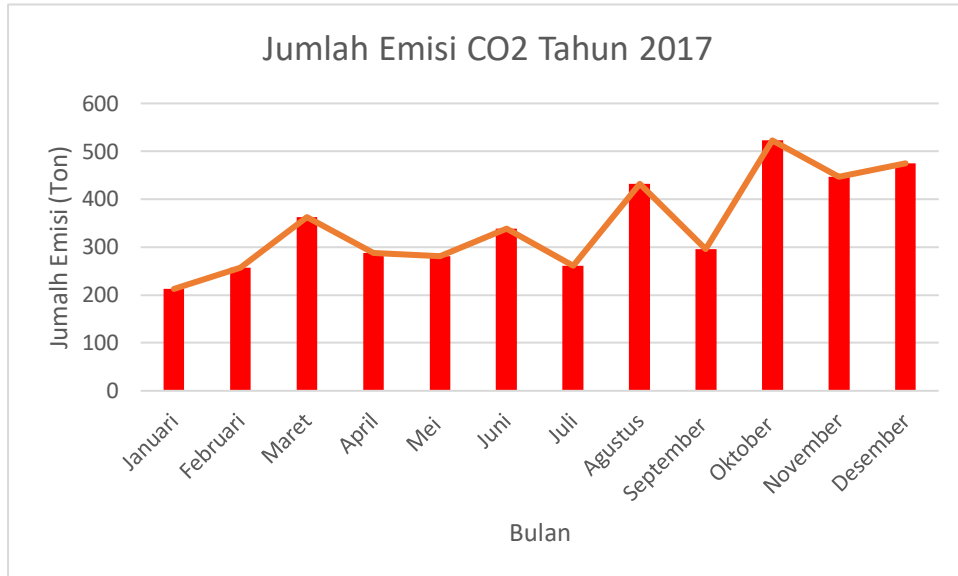


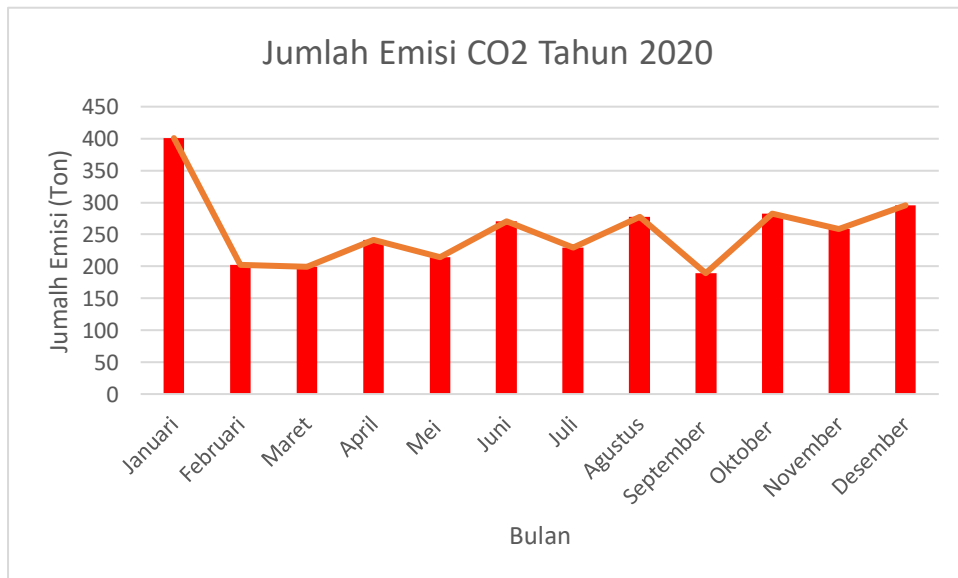
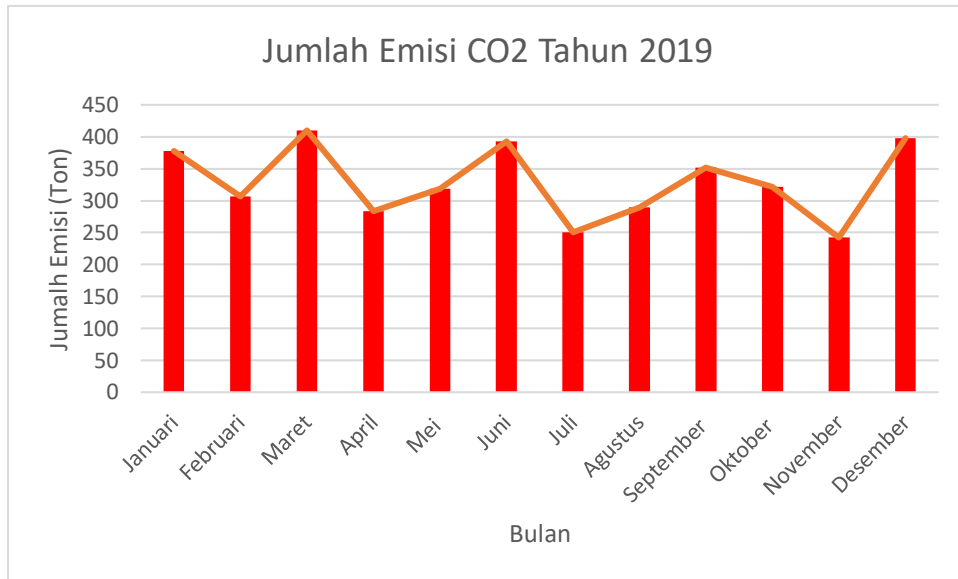


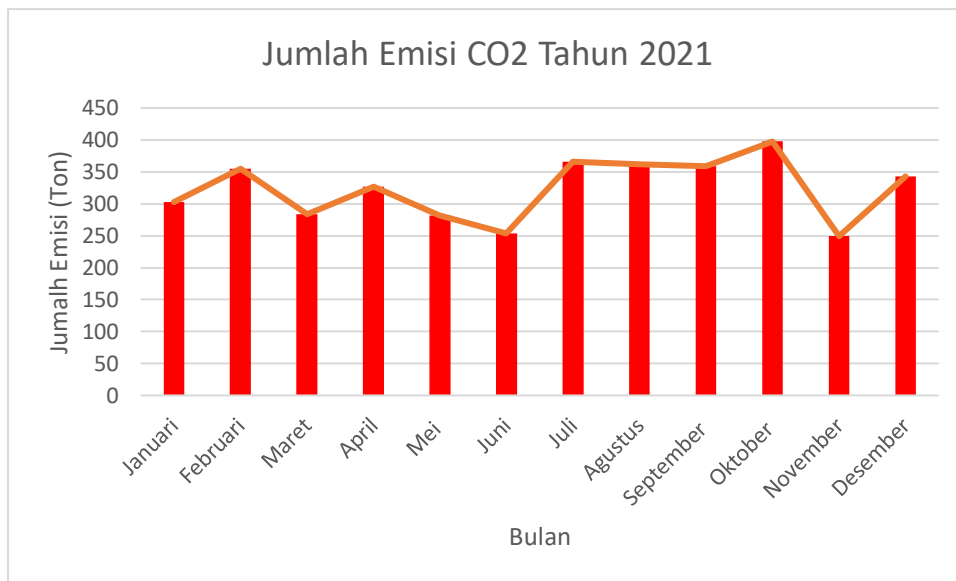




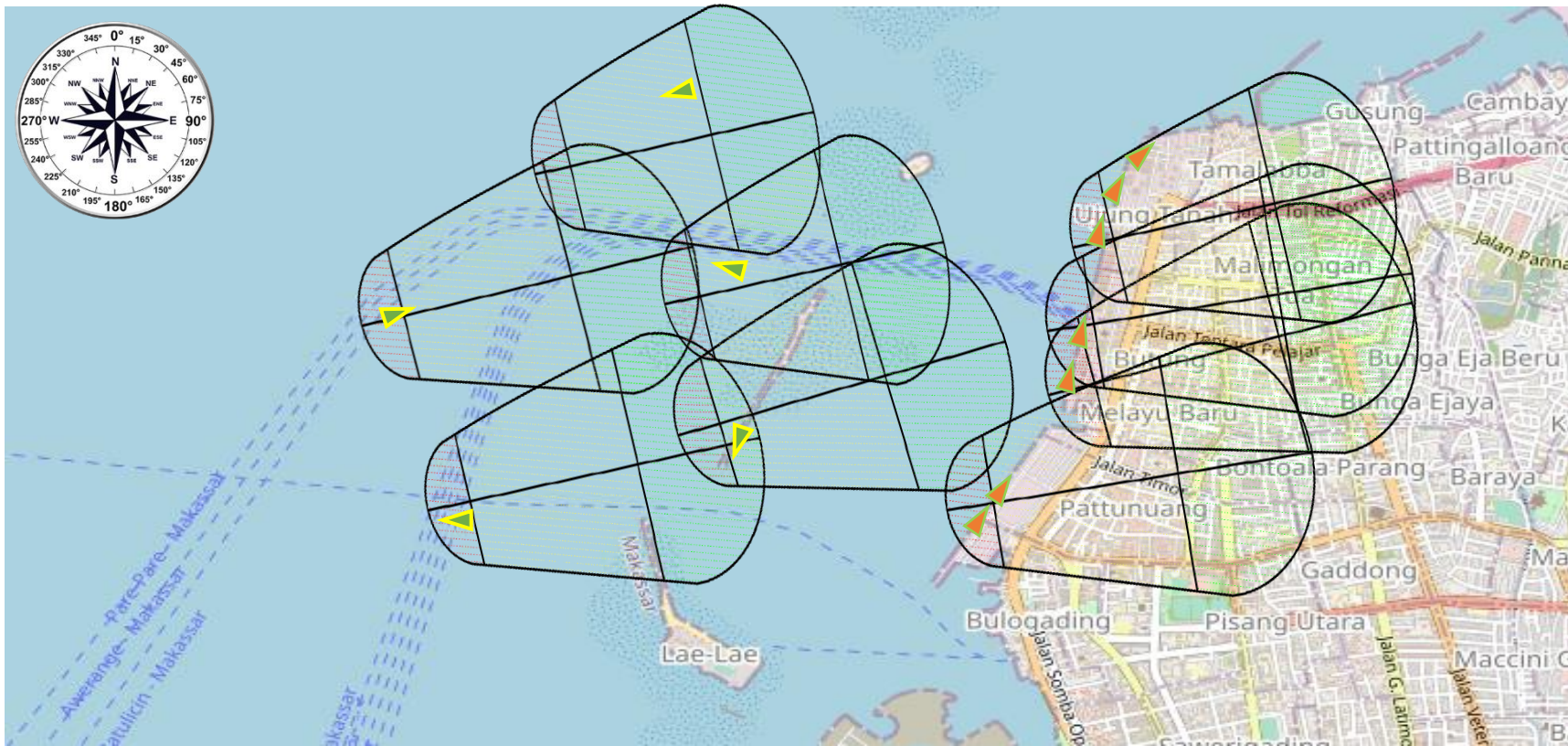









Lampiran 5. Gambaran Detail Area Sebaran Emisi pada Tanggal 2 Oktober 2017



 = status pelayaran *Manoeuvring*

 = status pelayaran *Hotelling*

Lampiran 6. Persentase Kadar Emisi Polutan dari Tahun 2017 sampai 2021

Jenis Emisi Polutan	Kadar Emisi Polutan											
	Tahun 2017		Tahun 2018		Tahun 2019		Tahun 2020		Tahun 2021		Rata-rata	
	<i>Manouvering</i>	<i>Hotelling</i>	<i>Manouvering</i>	<i>Hotelling</i>	<i>Manouvering</i>	<i>Hotelling</i>	<i>Manouvering</i>	<i>Hotelling</i>	<i>Manouvering</i>	<i>Hotelling</i>	<i>Manouvering</i>	<i>Hotelling</i>
NO ₂	2,86%	1,94%	3,10%	2,25%	2,75%	1,83%	2,41%	1,51%	2,57%	1,67%	2,74%	1,84%
SO ₂	0,20%	0,15%	0,28%	0,23%	0,18%	0,13%	0,15%	0,11%	0,16%	0,12%	0,19%	0,15%
PM _{2,5}	0,49%	0,26%	0,55%	0,29%	0,47%	0,24%	0,41%	0,16%	0,44%	0,20%	0,47%	0,23%
PM ₁₀	0,51%	0,27%	0,57%	0,31%	0,48%	0,25%	0,45%	0,20%	0,46%	0,22%	0,49%	0,25%
CO	0,52%	0,46%	0,58%	0,48%	0,48%	0,45%	0,46%	0,43%	0,47%	0,45%	0,50%	0,45%
CO ₂	12,27%	11,70%	12,29%	11,72%	12,25%	11,68%	12,22%	11,65%	12,24%	11,67%	12,25%	11,68%

Lampiran 7. Hasil Jumlah Emisi Gas Buang Setiap Jenis Kapal dari Tahun 2017 sampai 2021

Jenis Kapal	Jenis Emisi Polutan	Jumlah Emisi Gas Buang setiap Jenis Kapal (ton)				
		2017	2018	2019	2020	2021
<i>General Cargo</i>	NO ₂	56,601	56,063	39,120	47,995	43,147
	SO ₂	3,013	2,927	2,045	2,380	2,223
	PM _{2,5}	1,501	1,509	1,072	1,324	1,174
	PM ₁₀	1,450	1,459	1,013	1,229	1,089
	CO	6,065	6,099	4,279	5,389	4,664
	CO ₂	266,154	269,163	197,724	229,192	212,197
<i>Bulk Carrier</i>	NO ₂	135,755	139,946	123,832	101,107	116,891
	SO ₂	6,339	6,409	5,679	4,398	5,283
	PM _{2,5}	3,157	3,303	2,977	2,446	2,790
	PM ₁₀	2,787	2,918	2,568	2,074	2,364
	CO	11,704	12,038	11,935	8,706	11,597
	CO ₂	661,142	668,616	491,158	569,324	527,108
<i>Cement Carrier</i>	NO ₂	150,197	148,020	126,439	95,490	114,234
	SO ₂	7,014	6,779	5,798	4,154	5,162
	PM _{2,5}	3,493	3,493	3,039	2,310	2,726
	PM ₁₀	3,084	3,087	2,622	1,959	2,311
	CO	11,817	11,823	10,155	7,872	9,067
	CO ₂	619,448	623,286	560,498	399,938	492,731
<i>Container</i>	NO ₂	501,006	516,662	500,483	355,666	492,115
	SO ₂	15,815	15,715	15,515	10,459	15,034
	PM _{2,5}	7,876	8,099	8,134	5,817	7,940
	PM ₁₀	6,562	6,753	6,623	4,656	6,350

	CO	28,054	28,855	28,609	20,868	27,798
	CO ₂	1401,891	1450,167	1505,263	1010,666	1440,157
<i>Ro-Ro Cargo</i>	NO ₂	69,577	66,491	65,214	63,837	82,043
	SO ₂	5,868	5,500	5,402	5,016	6,697
	PM _{2,5}	1,657	1,607	1,606	1,582	2,005
	PM ₁₀	3,935	3,820	3,726	3,609	4,572
	CO	5,936	5,759	5,679	5,707	7,061
	CO ₂	293,475	286,345	295,659	273,443	361,923
	<i>Passenger</i>	NO ₂	20,234	18,853	22,959	15,965
SO ₂		0,008	1,088	1,327	0,875	1,060
PM _{2,5}		0,593	0,560	0,695	0,486	0,559
PM ₁₀		1,065	1,008	1,221	0,840	0,965
CO		2,657	2,513	3,077	2,196	2,465
CO ₂		105,191	100,070	128,291	84,284	101,186
<i>Tugs</i>	NO ₂	4,429	5,5024	4,797	4,594	5,160
	SO ₂	0,257	0,313	0,273	0,248	0,289
	PM _{2,5}	0,128	0,161	0,143	0,138	0,153
	PM ₁₀	0,116	0,146	0,127	0,120	0,133
	CO	0,562	0,709	0,621	0,611	0,660
	CO ₂	22,797	28,915	26,539	24,011	27,776
<i>Fishing</i>	NO ₂	10,546	11,792	11,898	8,204	11,155
	SO ₂	0,774	0,848	0,857	0,561	0,792
	PM _{2,5}	0,385	0,437	0,449	0,311	0,418
	PM ₁₀	2,295	2,607	2,616	1,784	2,392
	CO	2,020	2,292	2,326	1,646	2,155

	CO ₂	68,373	78,052	82,913	54,011	75,635
<i>Tanker</i>	NO ₂	88,453	106,766	86,185	70,369	81,354
	SO ₂	4,872	5,767	4,662	3,611	4,336
	PM _{2,5}	2,426	2,972	2,444	2,008	2,290
	PM ₁₀	2,020	2,476	1,988	1,606	1,830
	CO	10,126	12,408	10,072	8,441	9,395
	CO ₂	430,283	530,273	450,636	347,630	413,899
	<i>Other</i>	NO ₂	5,182	4,521	3,206	1,010
SO ₂		0,023	0,018	0,013	0,004	0,014
PM _{2,5}		1,725	1,515	1,104	0,399	1,256
PM ₁₀		1,531	1,345	0,957	0,340	1,070
CO		7,088	6,226	4,478	1,651	5,073
CO ₂		305,832	270,160	203,450	69,027	226,944

Lampiran 8. Data Iklim dan Jumlah Kapal pada Sebaran Emisi Tertinggi dari tahun 2017 sampai 2021

Tanggal	Kecepatan Angin (m/s)	Pagi/Siang	Malam	Kelas Kestabilan Udara	Suhu Udara Ambient	Derajat Arah Angin	Jumlah Kapal	
		Terik (<i>Intensity</i>) Matahari	Tutup Berawan				<i>Manouvering</i>	<i>Hotelling</i>
02 Oktober 2017	3	Sedang	-	B	30°C	250°	5	7
21 Nopember 2018	4	Sedang	-	B	29°C	200°	4	6
16 Maret 2019	3	Lemah	-	C	31°C	180°	3	7
04 Januari 2020	2	Sedang	-	B	29°C	230°	3	5
25 Oktober 2021	4	Sedang	-	B	28°C	200°	5	4

(Sumber: Kantor Wilayah IV BMKG Makassar dan Kantor VTS Makassar)

Lampiran 9. Grafik Hasil Prediksi Jumlah Emisi Gas Buang Jenis Polutan SO₂; PM_{2.5}; PM₁₀; CO; CO₂ pada Tahun 2022

