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AIR QUALITY OVERVIEW BASED ON NITROGEN DIOXIDE (NO_2) AND SULFUR DIOXIDE (SO_2) CONCENTRATION IN PROVINCE SOUTH SULAWESI

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ABSTRACT

Air quality is a parameter that measures the condition of air that is suitable for an area. The Air Quality Index (IKU) is one of the instruments that can be used to conduct a simple air quality assessment using several selected parameters, namely nitrogen dioxide (NO2) and sulfur dioxide (SO2). Air pollutant gases that impact health, especially the respiratory system, are NO2 and SO2. This study aims to determine the ambient air quality of nitrogen dioxide (NO2) and sulfur dioxide (SO2) based on the air quality index in 24 regencies/cities in South Sulawesi Province in 2015-2021. This study uses a quantitative research method with a descriptive approach. The data used is secondary data obtained from several sources such as government agencies and official government websites, namely the website of the Ministry of Environment and Forestry, DPLH (Environmental Management Service) of South Sulawesi Province and P3E SUMA (Sulawesi & Maluku Ecoregion Development Control Center). The results of this study indicate that air quality in 24 regencies and cities in Sulawesi Province based on the average Concentration of NO2 and SO2 parameters from 2015-2021 is still below the ambient air quality standard value based on Appendix VII of Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. Furthermore, the Air Quality Index (IKU) in 24 regencies and cities in South Sulawesi Province in 2015-2021 was, on average, in the good category. However, the government and related parties are expected to continue to take preventive measures so that the concentration of NO2 and SO2 in ambient air does not increase and that the air quality in South Sulawesi Province is always in good condition.

Keywords: Air Quality; Air Quality Index; South Sulawesi

1. INTRODUCTION

The environment is an important component of sustainable development, where air quality is a significant factor affecting the health of humans and other living things. Air is a basic necessity for life, yet air pollution is becoming increasingly pressing in many countries, especially developing countries such as Indonesia. Air pollution is caused by various factors, including human activities, topography, climate, weather and industrialization (Kautsar & Herlinda, 2021). In Indonesia, air pollution is a serious problem, along with population growth, urbanization, and an increase in the industrial sector. Based on data from the World Health Organization (WHO), nearly 9 out of 10 people are exposed to contaminated air daily, with outdoor air pollution responsible for 4.2 million premature deaths in 2019 (World Health Organization, 2022). This air pollution is becoming a global health threat, contributing to heart disease, respiratory disorders, lung cancer, stroke, and diabetes (Kautsar & Herlinda, 2021).

The primary pollutants that cause air quality degradation include nitrogen dioxide (NO2), sulfur dioxide (SO2), and fine particles such as PM2.5 and PM10. Nitrogen dioxide (NO2) gas belongs to the nitrogen oxide (NOx) group and is a pollutant that harms human health. NO2 can cause respiratory distress and inflammation of the lungs and potentially increase the risk of respiratory infections (Serlina, 2020). This gas is mainly produced by motor vehicles, power plants, and industrial processes that use fossil fuels (Masito, 2018). In addition to NO2, sulfur dioxide (SO2) is also an air pollutant that can irritate the respiratory tract, increase symptoms of asthma and bronchitis, and cause damage to human organs if exposed to high concentrations (Prabowo & Muslim, 2018; Yunita & Kiswandono, 2017). SO2 is usually produced from the combustion of fossil fuels, especially coal, oil, and exhaust gases from vehicles using diesel fuel (Masito, 2018). Exposure to these two pollutants, especially in the long term, can pose risks to public health, especially for individuals with respiratory disorders or chronic obstructive pulmonary disease (COPD).

In Indonesia, air quality in urban and industrial areas is often polluted due to increased motor vehicles and industrial activities. South Sulawesi, one of the most populous and rapidly growing provinces, is no exception to the air pollution problem. In 2021, the number of motorized vehicles in South Sulawesi was recorded at 3,707,880 units, which contributed significantly to the increase in air pollution (BPS South Sulawesi, 2022). In addition, burning fossil fuels by power plants and industrial plants also add to the concentration of air pollutants, especially NO2 and SO2, which impact air quality in the province (Dewi & Fitria, 2022). Economic growth and a growing population also worsen air quality, increasing the risk of health problems, especially in the respiratory system.

Air pollution in South Sulawesi needs serious attention, given its impact on public health. The Ministry of Health of the Republic of Indonesia reports that respiratory diseases, such as COPD, pneumonia, lung cancer and asthma, top the list of causes of death in Indonesia (Ministry of Health of the Republic of Indonesia, 2023). Therefore, proper air quality monitoring is essential to know how air pollution affects the province's public health conditions. This study aims to analyze the concentration of key pollutants, such as nitrogen dioxide (NO2) and sulfur dioxide (SO2), in 24 districts and cities in South Sulawesi and to determine the air quality index (AQI) from 2015 to 2021. The results of this study are expected to provide a clearer picture of air quality conditions in South Sulawesi, which can be the basis for air quality management and protection policies, as well as efforts to reduce the impact of pollution on public health.

2. METHODS

This research uses quantitative methods with a descriptive approach. Quantitative research is based on positivism, which assumes that observed phenomena can be classified and measured objectively (Sugiyono, 2013). The descriptive approach aims to describe or provide a systematic and accurate explanation of the nature or symptoms that occur in a particular population or region without testing the relationship between variables (Hardani et al., 2020). This research was conducted in South Sulawesi Province, covering 24 districts and cities, with data sourced from government agencies through secondary data. This research was conducted from December 2022 to February 2023, including data collection related to air quality from 2015 to 2021.

The population in this study is ambient air quality in 24 districts and cities in South Sulawesi Province. The air quality was measured based on nitrogen dioxide (NO2) and sulfur dioxide (SO2) parameters. This research sample consists of ambient air measurements with NO2 and SO2 parameters taken from 24 districts and cities in South Sulawesi Province during the 2015-2021 period.

The data collection method used is secondary data, which has previously existed and was collected from indirect sources, such as official documents or archives from government agencies. In this study, annual data on ambient air quality with NO2 and SO2 parameters were obtained from the website of the Ministry of Environment and Forestry and government agencies such as DPLH (Environmental Management Service) of South Sulawesi Province and P3E SUMA (Sulawesi & Maluku Ecoregion Development Control Center). Air quality monitoring is conducted using a passive sampler, a method of air sampling using a small device that requires no electrical power source and relatively low cost. It collects gases from the atmosphere using the principle of molecular diffusion. The passive sampler measures NO2 and SO2 concentrations as the main parameters in calculating the Air Quality Index (AQI).

The Microsoft Excel application analyzed data obtained from NO2 and SO2 measurements. The analysis was conducted by calculating the average Concentration of air parameters for each district/city and the entire South Sulawesi Province. The calculation was done to determine the annual average value of air quality based on monitoring results in various locations, such as transportation, industrial, residential and office areas.

3. RESULTS AND DISCUSSION

a) Overview of Nitrogen Dioxide (NO2) Concentration in South Sulawesi Province 2015-2021

From the observation of reports obtained on the website of the Ministry of Environment and Forestry, DPLH (Environmental Management Service) of South Sulawesi Province and

P3E SUMA (Sulawesi & Maluku Ecoregion Development Control Center), information was obtained regarding the average concentration of nitrogen dioxide parameters (NO_2) using the *passive sampler* method from 2015-2021. The data was obtained from 4 (four) sampling locations: transportation, industry, residential/residential areas, and offices. Then, the data was analyzed in the laboratory, and the results of the parameter data were averaged to get the average Concentration of NO_2, which has been converted into units of µg / m^3 as listed in the table below.

Based on the table below, it can be seen that the average concentration of nitrogen dioxide (NO_2) obtained from *passive sampler* measurements that the average Concentration of NO_2 from the results of these measurements when compared to the ambient air quality standard of 50 µg/m^3 for 1-year measurements listed in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management is still below the ambient air quality standard value. The average concentration of NO_2 in 24 districts/cities of South Sulawesi Province, namely Bantaeng Regency Concentration.The highest concentration in 2016 was 9.68 µg/m^3, and the lowest in 2018 was 2.41 µg/m^3. Kabupaten Barru had the highest concentration in 2015 at 11.89 µg/m^3 and the lowest in 2016 at 5.17 µg/m^3. Bone Regency had the highest concentration in 2016 at 12.95 µg/m^3 and the lowest in 2017 at 2.58 µg/m^3. The highest Concentration in Bulukumba Regency in 2016 was 7.41 µg/m^3, and the lowest concentration in 2017 was 4.70 µg/m^3. Enrekang Regency had the highest concentration in 2015 at 8.15 µg/m^3 and the lowest in 2017 at 3.05 µg/m3.

Table 1. Analysis Result of Passive Sampler Measurement of Nitrogen Dioxide (NO_2) Concentration per District/City in South Sulawesi Province 2015-2021

District/City	**Average Concentration of SO_2** (µg/m)^3					
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Bantaeng	9,68	3,10	2,41	5,58	5,42	6,31
Barru	5,17	6,85	6,70	7,68	8,12	7,43
Bone	12,95	2,58	3,49	4,08	7,46	6,35
Bulukumba	7,41	4,70	6,07	5,25	5,12	5,42
Enrekang	6,30	3,05	4,69	5,45	5,21	5,14
Gowa	15,23	19,89	15,17	12,79	13,98	12,80
Jeneponto	6,38	6,44	4,00	5,43	4,46	5,03
Kota Palopo	7,91	7,38	6,34	7,46	6,48	6,05
Kota Pare-pare	5,01	6,37	4,58	4,93	6,29	5,98
Luwu Timur	6,15	3,95	3,25	4,13	3,38	3,71
Luwu Utara	3,69	4,40	4,11	4,26	5,54	5,32
Luwu	9,20	5,92	2,28	3,21	2,98	3,33
Makassar	22,41	32,55	15,50	18,45	19,43	18,74
Maros	12,48	7,19	10,57	8,51	12,30	10,68
Pangkep	10,21	26,54	9,97	10,37	10,83	9,63
Pinrang	4,38	2,57	5,63	6,69	5,00	5,78

Selayar	13,80	7,75	7,31	6,34	6,64	6,42
Sidrap	7,43	6,78	6,12	7,68	8,27	8,19
Sinjai	10,35	6,34	6,20	5,53	5,99	6,14
Soppeng	8,02	6,30	6,10	4,16	5,84	5,48
Takalar	14,69	13,48	15,31	11,95	11,29	11,16
Toraja Utara	7,48	4,24	7,08	6,13	6,27	6,96
Toraja	10,26	7,61	7,33	6,46	6,17	5,80
Wajo	8,70	3,78	4,75	4,50	6,33	6,18

Secondary Data Source: Data from 2015-2018 was obtained from the Ministry of Environment and Forestry website (Ministry of Environment and Forestry, 2020). Data from 2019-2021 was obtained from DPLH and P3E SUMA agencies (South Sulawesi Provincial Environmental Management Service, 2022) and (Sulawesi & Maluku Ecoregion Development Control Center, 2022).

The highest concentration in 2015 was 24.38 μg/m^3, and the lowest in 2019 was 12.79 μg/m^3. Jeneponto District had the highest concentration in 2017 at 6.44 μg/m^3 and the lowest in 2018 at 4.00 μg/m^3. Palopo City had the highest concentration in 2016 at 7.91 μg/m^3 and the lowest in 2021 at 6.05 μg/m^3. Pare-Pare City had the highest concentration in 2017 at 6.37 μg/m^3 and the lowest in 2018 at 4.58 μg/m^3. East Luwu Regency's highest concentration in 2015 was 6.80 μg/m^3, and the lowest in 2018 was 3.25 μg/m^3. North Luwu Regency had the highest concentration in 2020 at 5.54 μg/m^3 and the lowest in 2016 at 3.69 μg/m^3. Luwu Regency, the highest concentration in 2016 was 9.20 μg/m^3, and the lowest in 2018 was 2.28 μg/m^3. Makassar City had the highest concentration 2017 at 32.55 μg/m^3 and the lowest in 2018 at 15.50 μg/m^3. Maros Regency had the highest concentration in 2016 at 12.48 μg/m^3 and the lowest in 2017 at 7.19 μg/m^3. Pangkep Regency had the highest concentration in 2017, 26.54 μg/m^3 and the lowest concentration in 2021, 9.63 μg/m^3

Pinrang Regency had the highest concentration in 2019 at 6.69 μg/m^3 and the lowest in 2017 at 2.57 μg/m^3. Selayar Islands Regency had the highest concentration in 2016 at 13.80 μg/m^3 and the lowest in 2019 at 6.34 μg/m^3. Sidrap district had the highest concentration in 2020 at 8.27 μg/m^3 and the lowest in 2018 at 6.12 μg/m^3. Sinjai Regency had the highest concentration in 2016 at 10.35 μg/m^3 and the lowest in 2019 at 5.53 μg/m^3. Soppeng Regency had the highest concentration in 2016 of 8.02 μg/m^3 and the lowest in 2019 of 4.16 μg/m^3. Takalar Regency had the highest Concentration in 2018, 15.31 μg/m^3 and the lowest Concentration in 2021, 11.16 μg/m^3. North Toraja Regency had the highest concentration in 2016 at 7.48 μg/m^3 and the lowest in 2017 at 4.24 μg/m^3. Toraja Regency had the highest concentration in 2016, 10.26 μg/m^3 and the lowest in 2021, 5.8 μg/m^3. Wajo Regency had the highest concentration in 2015, 11.63 μg/m^3 and the lowest in 2017, 3.78 μg/m^3.

Major air pollutants in urban areas include SO_2, NO, NO_2, CO, O_3, suspended particles and Pb, with particulates and nitrogen dioxide (NO2) being the most toxic (Male, 2021; Dwirahmawati et al., 2018). NO_2, produced from fuel combustion, contributes to ozone and acid rain formation and triggers photochemical haze (World Health Organization, 2022). The transportation sector accounts for 69% of NO_2 pollution in urban areas (Izzati et al., 2021). The NO_2 concentration in Makassar City, although still below the quality standard, shows the highest value in South Sulawesi Province, influenced by the increasing number of vehicles (BPS South Sulawesi Province, 2022). The increase in motorized vehicles plays a significant role in NO_2

pollution, with similar impacts found in Bandung (Dwirahmawati et al., 2018; Indrawati et al., 2019). Makassar city also has industrial areas that contribute to NO_2 pollution, especially in Makassar Industrial Estate (Kurniawan et al., 2023). Meteorological factors such as temperature, humidity, and wind speed affect NO_2 concentrations, where low temperature, high humidity, and weak winds increase NO_2 concentrations (Syech et al., 2013; Riyanti et al., 2018; Herawati et al., 2018). Exposure to NO_2 poses a high risk to human health, especially the lungs, which can cause severe respiratory disorders such as inflammation of the respiratory tract, bronchitis and pneumonia, with NO_2's toxicity being four times greater than that of NO gas (Herawati et al., 2018).

b) Overview of Sulfur Dioxide (SO2) Concentrations in South Sulawesi Province 2015-2021

From the observation of reports obtained on the website of the Ministry of Environment and Forestry, DPLH (Environmental Management Service) of South Sulawesi Province and P3E SUMA (Sulawesi & Maluku Ecoregion Development Control Center), information was obtained regarding the average concentration of sulfur dioxide parameters (SO_2) using the *passive sampler* method from 2015-2021.

Based on the table below, it can be seen that the average concentration of sulfur dioxide (SO_2) obtained from *passive sampler* measurements that the average Concentration of SO_2 from the results of these measurements when compared to the ambient air quality standard of 45 μg/m^3 for 1-year measurements listed in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management is still below the ambient air quality standard value.

The districts/cities of South Sulawesi Province, namely Bantaeng Regency, had the highest concentration in 2017, 12.33 μg/m^3, and the lowest concentration in 2021, 4.89 μg/m^3. Barru Regency has the highest concentration in 2016, 12.97 μg/m^3 and the lowest concentration in 2015, namely 3.33 μg/m^3. Bone Regency had the highest concentration in 2021, 9.05 μg/m^3 and the lowest in 2019, 3.32 μg/m^3. Bulukumba district has the highest Concentration in 2017, 13.51 μg/m^3 and the lowest in 2016, 8.95 μg/m^3. Enrekang Regency had the highest concentration in 2016, 9.21 μg/m^3 and the lowest in 2021, 5.49 μg/m3.

Gowa Regency had the highest concentration in 2017, 12.30 μg/m^3 and the lowest in 2015, 2.77 μg/m^3. Jeneponto district had the highest concentration in 2016, 12.01 μg/m^3 and the lowest in 2021, 7.39 μg/m^3. Palopo City had the highest concentration in 2017, 11.81 μg/m^3 and the lowest in 2019, 7.60 μg/m^3. Pare-Pare City had the highest concentration in 2016 at 11.34 μg/m^3 and the lowest in 2019 at 5.19 μg/m^3. East Luwu Regency had the highest concentration in 2015 at 8.95 μg/m^3 and the lowest in 2016 at 7.07 μg/m^3. The highest concentration in North Luwu Regency in 2018 was 11.51 μg/m^3, and the lowest in 2017 was 5.19 μg/m^3. The highest Concentration in Luwu Regency in 2018 was 10.69 μg/m^3 and the lowest in 2015 was 4.07 μg/m^3. Makassar City had the highest concentration in 2017 at 17.29 μg/m^3 and the lowest in 2015 at 3.03 μg/m^3. Maros Regency had the highest concentration in 2016 at 13.20 μg/m^3 and the lowest in 2018 at 5.34 μg/m^3. Pangkep district had the highest concentration in 2018, 16.25 μg/m^3 and the lowest concentration in 2016, 9.06 μg/m .^{3}

Table 2. Analysis Results of *Passive Sampler* Measurements of Sulfur Dioxide (SO_2) Concentrations by District/City in South Sulawesi Province 2015-2021

District/City	Average Concentration of SO_2 (µg/m)^3					
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Bantaeng	10,03	12,33	5,56	5,15	5,55	4,89
Barru	12,97	5,22	5,40	4,67	6,72	5,67
Bone	7,99	4,10	3,61	3,32	7,74	9,05
Bulukumba	8,95	13,51	11,44	10,71	9,87	11,07
Enrekang	9,21	7,50	6,58	5,99	5,83	5,49
Gowa	9,38	12,30	8,24	6,26	8,63	7,98
Jeneponto	12,01	10,25	10,56	10,66	8,01	7,39
Kota Palopo	10,56	11,81	7,60	8,39	9,59	9,21
Kota Pare-pare	11,34	5,48	5,44	5,19	9,71	8,47
Luwu Timur	7,07	7,27	8,64	8,43	7,39	7,78
Luwu Utara	5,25	5,19	11,51	9,50	9,26	8,96
Luwu	8,62	9,67	10,69	5,53	9,96	9,44
Makassar	14,13	17,29	11,93	10,64	12,54	11,94
Maros	13,20	6,03	5,34	8,61	9,64	9,49
Pangkep	9,06	11,60	16,25	15,41	12,04	12,26
Pinrang	12,79	5,18	4,15	3,97	5,54	4,33
Selayar	7,39	9,09	12,84	12,22	8,74	10,04
Sidrap	11,76	11,91	6,89	9,35	8,84	8,68
Sinjai	7,14	8,96	7,91	7,74	7,53	7,67
Soppeng	7,27	6,82	7,82	6,48	6,00	5,67
Takalar	8,73	3,92	9,05	8,06	8,68	8,72
Toraja Utara	7,37	8,57	7,03	8,34	8,35	6,94
Toraja	5,86	10,00	10,38	10,40	9,31	9,03
Wajo	9,31	18,90	7,37	7,11	7,51	7,04

Secondary Data Source: *Data from 2015-2018 were obtained from the Ministry of Environment and Forestry website* (Ministry of Environment and Forestry, 2020). *Data from 2019-2021 were obtained from DPLH and P3E SUMA agencies* (South Sulawesi Provincial Environmental Management Service, 2022) and (Sulawesi & Maluku Ecoregion Development Control Center, 2022).

Pinrang Regency had the highest concentration in 2016 at 12.79 µg/m^3 and the lowest in 2019 at 3.97 µg/m^3. Selayar Islands Regency had the highest concentration in 2018 at 12.84 µg/m^3 and the lowest in 2016 at 7.39 µg/m^3. Sidrap district had the highest concentration in 2017 at 11.91 µg/m^3 and the lowest in 2018 at 6.89 µg/m^3. Sinjai Regency had the highest concentration in 2017 at 8.96 µg/m^3 and the lowest in 2016 at 7.14 µg/m^3. Soppeng Regency had the highest concentration in 2018, 7.82 µg/m^3 and the lowest in 2021, 5.67 µg/m^3. Takalar Regency had the highest concentration in 2015, 10.79 µg/m^3 and the lowest in 2017, 3.92 µg/m^3. The highest concentration in North Toraja Regency in 2017 was 8.57 µg/m^3, and the lowest in 2021 was 6.94 µg/m^3. Toraja district has the highest concentration in 2019, 10.40 µg/m^3 and the lowest in 2016, 5.86 µg/m^3. Wajo district had the highest concentration in 2017, 18.90 µg/m^3 and the lowest in 2015, 2.48 µg/m3.

SO_2 is a sulphur oxide gas formed when burning sulphur-containing fossil fuels, such as coal, oil and gas. SO_2 has the potential to cause acid rain, which damages crops and materials and reduces visibility due to fog formation. In addition, SO_2 can react to form sulfate particulates or aerosols that are harmful to human health, especially the respiratory system (Ministry of Environment, 2013; Arini et al., 2023). In urban areas, SO_2 comes from significant sources such as coal-fired power plants, diesel-fueled motor vehicles, and fossil fuel-using industries. These activities produce SO_2 emissions that impact ambient air quality (DPLH South Sulawesi Province, 2021). SO_2 can irritate the respiratory tract, and the impact is worse for people with asthma, children and the elderly. In addition, SO_2 converted to sulfate aerosols can cause more serious respiratory problems (Ministry of Environment, 2013). Controlling SO_2 emissions from the transportation and industrial sectors is important, as it requires using cleaner combustion technologies and environmentally friendly fuel policies to reduce its adverse impacts on health and air quality (Maherdyta et al., 2022).

c) Analysis of Air Quality Index (AQI) in 24 Districts/Cities of South Sulawesi Province 2015-2021

The District/City Air Quality Index (AQI) value is the average result of all air monitoring locations in its administrative area. This air monitoring focuses on nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) parameters obtained from 4 sampling points and then analyzed in the laboratory, and the average results of the parameter data have been converted into units of $\mu g/m^3$. This air monitoring data is sourced from secondary data obtained on the website of the Ministry of Environment and Forestry, DPLH (Environmental Management Service) of South Sulawesi Province and P3E SUMA (Sulawesi & Maluku Ecoregion Development Control Center).

Based on the results of the Air Quality Index (AQI) analysis from 2015 to 2021 in South Sulawesi Province, air quality in various districts/cities showed significant variations. In 2015, four districts had air quality in the outstanding category, such as Barru, Bone, Luwu, and Wajo, with the highest IKU value in Bone (95.17). In 2016, air quality improved in several districts, with North Luwu recording the highest KPI value (95.70), but Makassar City recording the lowest value (70.37) in the poor category. In 2017, air quality improved more evenly, with Bone Regency achieving the highest score (98.07) and Makassar City recording the lowest score (58.94). The following year, 2018, air quality in South Sulawesi was still quite good, with Bone again achieving the highest score (98.12), while Makassar remained in the fair category. In 2019, Bone's air quality remained superior, with a score of 98.11, and Makassar City showed a slight improvement with a score of 77.97.

In 2020, Pinrang Regency recorded the best air quality with a KPI score of 94.39, while Makassar City remained in the fair category (74.65). 2021 showed stability in air quality, with Pinrang again recording the highest score (95.53) and Makassar City remaining in the fair category (75.96). Overall, air quality in South Sulawesi Province shows a varied but relatively good trend in most areas, with some districts, such as Bone, Luwu, and Pinrang, consistently recording excellent air quality from 2015 to 2021.

Air quality is essential for the survival of living things, especially humans. In Indonesia, air quality in several cities is declining due to various factors, such as rapid industrial growth and the development of motorized vehicles that are not proportional to the growth of green open space and preservation of green areas, especially in urban areas (Prayudha et al., 2018). The increase in motorized vehicles and industries leads to increased air pollution that can harm human, animal and plant health. Therefore, attention to air quality is significant, especially in densely populated urban areas.

The physical development of cities and industrial centres, as well as the development of transportation, has resulted in changes in air quality due to air pollution. Air pollution is the entry of polluting substances, either in the form of gases or small particles (aerosols), into the air in large enough quantities over a long period so that it can interfere with the lives of living things. According to Yunita and Kiswandono (2017), air pollution is a problem that needs serious attention, especially in big cities with dense populations and industrial activities. Therefore, air quality monitoring is one way to identify and deal with air pollution (Maherdyta et al., 2022).

One of the methods used to monitor air quality is the Air Quality Index (AQI), which is part of the 2019 Environmental Quality Index (EQI). The IKU measures air pollution and provides easy-to-understand information to the public regarding air quality conditions in certain areas. In addition, KPI is also the basis for formulating air quality management policies to protect humans and ecosystems (Pradifan et al., 2021). The KPI calculation method generally uses five main parameters, namely surface ozone, particulate matter, carbon monoxide (CO), sulfur dioxide (SO2), and nitrogen dioxide (NO2). However, in the IKLH calculation, only two parameters are used, namely NO2 and SO2. NO2 represents emissions from motor vehicles using gasoline fuel, while SO2 comes from industrial emissions and motor vehicles using diesel fuel and other sulfur-containing fuels.

Air quality monitoring in urban and district areas uses the manual passive sampler method. This method does not require electricity and high operational costs and can be placed in remote areas, allowing for more spatial and temporal monitoring. Gas sampling depends on the diffusion of gas into the absorbent medium. The advantage of this passive method is that it can provide more uniform information about air quality in an area (Indrawati et al., 2021). Based on the calculation of KPIs in South Sulawesi Province in 2015-2021, air quality in 24 districts/cities showed quite good results. Bone District, for example, was recorded as having the best air quality, with a KPI value of 98.12 in 2018. The district has made various efforts to manage air quality, such as the implementation of Car Free Day (CFD) and Regent regulations related to air quality control, including the establishment of ambient air quality standards, periodic testing of vehicle exhaust emissions, and monitoring of air quality in the district. The regulations implemented aim to maintain air quality in good condition and reduce air pollution that can impact public health (Environmental Agency of Bone Regency, 2019).

The same is true for North Luwu District, which in 2016 was recorded as having the highest air quality KPI value of 95.70. Air quality in this district is influenced by several factors, such as the growth in the number of vehicles and fuel consumption, as well as the activities of the palm oil industry, power plants, and health facilities. Nonetheless, air quality in the district is well maintained, largely thanks to air quality management policies implemented since 2017, such as Car Free Day regulations and tree protection in green open spaces (North Luwu District Environment Office, 2017). In addition, North Luwu District also has a forest-dominant area, which positively impacts air quality, with around 66% of its area having preserved forest cover. Good regional spatial management also plays a role in maintaining air sustainability in this district.

Efforts to improve air quality in these areas also involve preparing air pollution control plans, such as preparing emission inventories to map pollutant sources. Emission source control is carried out through more environmentally friendly transportation management, increased mass transportation, periodic vehicle emission tests, and restrictions on the age and type of vehicles operating in certain areas. In addition, continuous monitoring of ambient air quality efforts to tackle forest fires and developing green open spaces also support efforts to restore air quality in the area (Environmental Quality Index, 2019).

From an Islamic perspective, air pollution and environmental degradation, in general, are not only seen as physical problems but are also linked to the concept of *fasad* in the Qur'an, which means damage or deviation from the balance of nature. This concept of *fasad* includes damage to the body, soul and environment. Islam teaches to maintain balance and prohibits damaging the environment, including air, as part of the human responsibility to take care of nature that has been created as well as possible (Fauziah, 2020; Nurhayati et al., 2018). This shows that in Islam, maintaining air quality and the environment is part of every individual and society's moral obligations.

Overall, air quality management in regions in Indonesia, such as South Sulawesi, shows serious efforts in maintaining air quality through various policies and monitoring methods. However, it is important to continue monitoring and improving efforts to reduce air pollution through government policies, community participation, and sustainable environmental protection.

4. CONCLUSION

The study on air quality in South Sulawesi Province from 2015 to 2021 reveals that the concentrations of nitrogen dioxide (NO2) and sulfur dioxide (SO2) across 24 districts/cities remained below the ambient air quality standards set by Indonesian regulations. Most areas consistently recorded air quality in the "good" category based on the Air Quality Index (AQI), with occasional fluctuations between "fair" and "very good." Key sources of NO2 pollution were motor vehicle emissions, industrial activities, and power plants, while SO2 primarily originated from industrial processes, diesel vehicles, and fossil fuel combustion. Urban centres, such as Makassar City, displayed higher levels of air pollution due to the dense population, increasing vehicle numbers, and industrial activities. Despite the generally good air quality, ongoing efforts are essential to prevent an increase in pollutant concentrations, ensuring the preservation of the region's public health and environmental quality.

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