Phys. Comm. 7 (1) 2023 : 28 - 34

Physics Communication

http://journal.unnes.ac.id/nju/index.php/pc

Analysis of Kendal Industrial Estate (KIK) impact on the Surrounding Air Quality

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Article Info

Article history:
Submitted 25 December 2022
Revised 28 February 2023
Accepted 28 February 2023

Keywords:
air pollution, Kendal Industrial Area, KIK, air quality

Abstract

The Kendal Industrial Area (KIK) is developed to accelerate economic development in the Kendal district area and to support the acceleration and expansion of economic development. Industrialization will lead to a process of air pollution which is marked by 16 companies that are already operating in the KIK area. This research was aimed to analyze the impact of the Kendal Industrial Estate on air quality. The approach of this research used descriptive method, with an analysis of changes in air quality that occurred before the existence of KIK and after the development of industrial areas. The factors that affect the air quality conditions reviewed in this study were air temperature, surface pressure, wind speed, and relative humidity. Data collection techniques used were secondary data NASA satellite imagery. The results showed that there is a change in air conditions after the presence of KIK as indicated by the increase in air pressure and air temperature and the decrease in relative humidity and wind speed. The results indicates that the existence of the Kendal Industrial Area (KIK) causes changes in environmental conditions, but these changes are not significant so they are still within the comfort limits for industrial areas.

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p-ISSN 2528-5971
e-ISSN 2528-598X

INTRODUCTION

Based on Government Regulation No. 85 of 2019 concerning the Kendal Special Economic Zone, the government stipulates the existence of a new industrial area to accelerate economic development in the Kendal Regency area. The development of the Kendal Industrial Estate (KIK) has a positive effect on increasing investment in Indonesia which supports national economic development. However, the development of industrial estates will certainly harm the environment due to land conversion for industrial estates. The results of research by Baihaqi et al. (2019) show that changes in land use result in changes in surface temperature increase. This has an impact on air quality in the KIK area, which has changed due to land conversion. In line with that, the results of Arif Rahman's research (2022) show that the more factories the more air pollutants will increase which further results in the decrease of air quality. Therefore, the conversion of land into factories could affect the surface temperature and air quality in the KIK area.

Industrialization will certainly have impacts on air quality. One of them is air pollution, which is caused by air pollutant substances in the form of solid, liquid, or gas particles. Air that has been polluted by pollutants not only affects human health and all living things but also the environment around (Jainal & Ferawati, 2019). The same thing was explained by Rakhman et al (2015) that air pollution would result contaminated air and affects life. Therefore, Investigation of air quality in KIK area is important to determine prevention efforts so that it does not affect health.

This research is aimed to study the effect of the Kendal Industrial Area (KIK) on air quality. Air pollution can be identified from the physical properties of the air, which are related to air pressure and temperature, wind speed, and air humidity. Surface pressure depends on the weight of the air above it. By the presence of air pollutants, the weight of the air will be greater, which will increase the surface pressure. The earth's surface absorbs heat through water vapor and other air pollutants. The air temperature will increase if the condition of water vapor and air pollutants increased. An increase in surface temperature and pressure results in the decrease of wind speed. Air humidity is affected by air temperature and water vapor conditions. The increase of temperature and water vapor causes the maximum water vapor pressure to increase Which further results in the decrease of the relative humidity.

METHODS

The research approach used in this study was a quantitative approach with descriptive methods. This research was conducted in the Kendal Industrial Area (KIK) Kendal Regency, Central Java. The dependent variables were surface pressure, air temperature, relative humidity, and wind speed while the independent variables are the Kendal Industrial Area and the data collection periode which were from before construction (2012-2013) and after construction (2017-2019). Data collection was carried out by using secondary data from the Power Data Access Viewer resulting from satellite imagery from NASA. The data obtained were then compared before and after construction.

RESULTS AND DISCUSSION

1. Surface Pressure Analysis

The surface pressure data for each month from 2012-2013 and 2017-2019 are presented in Table 1. Based on the results show in the Table 1. the average value of surface pressure (in kPa). Before the construction tends to be smaller than the surface pressure after development. In addition, the construction of KIK shows that there is an increase in average surface pressure every year. The increase in surface pressure is caused by the presence of air contaminants causing the weight of the air to be greater so that the impact on the surface pressure becomes higher. The air pollutant were produced by industrial activities in KIK.

Table 1. Surface Pressure Data in KIK Area

Month	Pressure in Years (kPa)				
	2012	2013	2017	2018	2019
January	97,23	97,33	97.29	97.16	97.38
February	97,22	97,25	97.37	97.37	97.5
March	97,25	97,38	97.38	97.3	97.42
April	97,39	97,3	97.4	97.33	97.34
May	97,34	97,33	97.4	97.39	97.44
June	97,42	97,24	97.47	97.48	97.45
July	97,43	97,38	97.51	97.45	97.5
August	97,51	97,47	97.46	97.49	97.52
September	97,48	97,43	97.46	97.48	97.56
Oktober	97,38	97,46	97.36	97.45	97.4
November	97,33	97,26	97.18	97.39	97.36
Desember	97,23	97,25	97.28	97.33	97.34
Annual	97,35	97,34	97,38	97,39	97,43

KIK covers an area of 2,200 ha and absorbs nearly 500,000 workers. The amounts of workers is in line with the amount of the transportations in which it also contributes gases to the air causing the surface pressure in Kendal city to increase. The growing development of industrial and transportation activities will cause environmental pollution that affects air quality (Helmy, 2019). More carbon is produced from various urban activities such as transportation and industry, which are the largest consumers of fossil fuels that release carbon from their combustion. These two activities contribute to the release of emissions in the form of CO2 gas which has an impact on reducing air quality.

In addition, the absorption of labor was accompanied by the increase of housing which reduce the agricultural area (green area). The un-controlled change of the land usage may cause social, economic, and environmental problems (Wardana, 2016). The use of natural land for industrial buildings can be a problem that can affect environmental stability (Nugraha, 2015). Therefore, the KIK experiences air pollution which can be seen from the increase of surface pressure every year. However, the increase is not too significant, indicating that the pollution that occurs is relatively small.

2. Air Temperature Analysis

The air temperature data for each month from 2012-2013 and 2017-2019 are presented in Table 2. Based on Table 2. It can be seen that the average air temperature before the construction was more stable, while after the KIK construction the average temperature increased each year. In 2018, the average air temperature increased by 0.37˚C from 2017. Meanwhile, in 2019, the average air temperature increased by 0.31˚C from 2018. This data shows that the operation of KIK has caused the average air temperature in the KIK area which is in parts of the Kaliwungu area to increased. These results are consistent with Pratiwi's research (2020), which shows that there has been an increase in soil surface temperature in Kaliwungu District from 2010 – 2019. Whereas the results show that the surface temperature in Kaliwungu District was in range of 20-23 ˚C. While the results in 2019 shown the lowest surface temperature in around 20-23˚C and the highest in the 35-38˚C. Based on this research, it shows that the Kendal Industrial Area, which was originally a green area, began to experience an annual average temperature increase. However, the increase was not significant since the area was built and developed. According to Wikaningrum (2015), the quality of the environment within a radius of 2500 m is estimated to be affected by industrial areas. Therefore, a good management system is needed to anticipate the negative effect.

Table 2. Air Temperature Around KIK area

Month	The Temperature in Years (˚C)				
	2012	2013	2017	2018	2019
January	25,01	24,92	25.23	25.35	25.91
February	25,33	25,33	25.13	25.18	25.79
March	25,25	26	25.69	25.8	25.87
April	25,71	26,08	25.95	26.21	26.53
May	25,63	26,06	26.05	26.13	26.36
June	24,96	25,71	25.55	25.75	25.51
July	24,73	24,8	25.11	25.41	25.52
August	25,68	24,93	25.78	26.12	26.17
September	27,03	25,85	27.01	27.47	27.27
Oktober	27,16	26,9	26.59	27.92	28.33
November	26,66	26,37	26.31	27.12	28.18
Desember	25,76	25,65	25.88	26.2	27.01
Annual	25,74	25,72	25,86	26,23	26,54

High air temperatures will cause dust particles and pollutants floating in air much longer than in the low air temperature. This is because, at high temperatures, dust particles and pollutants will be lighter and last longer in the air in a turbulent state. The increase in air temperature in the KIK area may continue to increase in the future in line with the pace of industrial activities. Thus, if it is not accompanied by efforts to manage and prevent air pollutants, it can harm the environment.

According to SNI (Indonesian National Standard) data, the maximum effective air temperature is 20.5˚C as a cold threshold and 31˚C as a hot as shown in Table 3. The level of air temperature outside this threshold will reduce the level of work productivity and the quality of workers' health. In Table 3, it shown that the annual average air temperature before the construction of industrial estates was in the range of 25 ˚C at optimal comfort level. After construction, starting in 2018, the average year temperature increased to 26˚C which is in the comfortable warm category. This means that there is an increase in air temperature after KIK operated. However, the increase is not significant so the air pollution is still below maximum limits that do not interfere with health and work productivity.

Table 3. Threshold of Comfortable Temperature

	Effective Air Temperature
Comfortable cool	20,5 ˚C – 22,8 ˚C
• Upper Threshold	24 ˚C
Optimal Comfort	22,8 ˚C – 25,8 ˚C
• Upper Threshold	28 ˚C
Comfortable Warm	25,8 ˚C – 27,1 ˚C
• Upper Threshold	31 ˚C

Source: SNI 03-6572-2001, Tata cara perancangan sistem ventilasi dan pengkondisian udara pada bangunan gedung

3. Relative Humidity Analysis

The relative humidity data for each month from 2012-2013 and 2017-2019 are presented in Table 3. Air humidity is the amount of water vapor contained in the air or atmosphere. Water vapor in the atmosphere can change into liquid or solid form and ends up falling to earth as rain. The amount of air humidity indicates that the air contains a lot of water vapor, or the air is wet (Fadholi, 2013). Based on the results of the data presented in Table 4, the humidity before KIK development tends to increase. Meanwhile after the construction tends to decrease each year. The average air humidity after the construction of KIK in 2017 was 80.44%, dropping to 76.38% in 2018 and dropping again to 74.81% in 2019. The decrease in air humidity at KIK shows that there has been a decrease in the average moisture content in the air which causing the air become drier.

Table 4. Relative Humidity Data in KIK Area

Month	Relative Humidity in Years (%)				
	2012	2013	2017	2018	2019
January	86,19	89,25	86.25	85.31	84.75
February	84,25	86,88	87.44	87.06	85.0
March	85,06	83,94	83.19	82.5	82.94
April	83,19	83,88	83.12	82.62	83.56
May	81,19	83,69	82.56	80.06	80.44
June	80,5	84,12	82.0,	77.81	76.75
July	74,69	84,12	79.88	71.38	71.19
August	66,88	78,31	72.25	65.62	65.56
September	62,94	73,38	68.25	61.69	61.25
Oktober	71,19	71,06	77.69	65.56	61.25
November	78,69	76,94	80.38	75.81	66.62
Desember	84,19	82,12	82.56	81.56	79.0
Annual	78,25	81,44	80,44	76,38	74,81

A decrease in the relative humidity of the air can affect microorganisms that live in the surrounding environment. The higher the humidity, the better it is for microorganisms to grow and reproduce since air humidity indirectly affects the oxygen supply. Low air humidity will cause nutrients to be leached out, air volume will decrease, resulting in reduced microorganism activity and anaerobic fermentation will occur which will cause an unpleasant odor (Febriana Rina, 2013). Therefore, a decrease in air humidity in KIK indicates a change in air composition, one of the causes of pollution. However, the decrease is still within limits that do not interfere with the activities of living things.

4. Wind Speed Analysis

The wind speed data for each month from 2012-2013 and 2017-2019 are presented in Table 4. The concentration of a pollutant in the atmosphere is strongly influenced by wind speed. The greater the wind speed, the concentration of pollutants emitted by a source will be greater with smaller distribution distances. In general, pollutants will collect around the maximum distance from the emission source, then spread with decreasing concentrations to a considerable distance from the pollutant source. Based on the results of the data presented in Table 5, It is shown that before the construction of the KIK the average wind speed increased, whereas after the construction was carried out it showed that the average wind speed decreased each year. The average wind speed after the construction of KIK in 2017 was 2.73 m/s, decreasing to 2.65 m/s in 2018 and dropping again to 2.57 m/s in 2019. This shows that there are air pollutants in the atmosphere.

According to Febriana (2013), wind speed determines how much-polluted air is mixed since wind speed and direction determine the rate of spread of pollutant materials. This factor determines how fast and how much an area experiences air pollution. The greater the wind speed, the faster the pollutant levels will be low due to mixing with the surrounding air after the material leaves the source.

Table 5. Wind Speed Data in KIK Area

Month	Wind Speed in Years (m/s)				
	2012	2013	2017	2018	2019
January	4,15	4,38	3.2	3.7	3.29
February	2,24	3,49	3.59	3.09	1.91
March	3,61	2,53	2.55	2.31	2.52
April	2,16	2,3	1.97	2.37	2.16
May	2,7	2,1	2.53	2.88	2.7
June	2,8	2,08	2.66	2.73	2.85
July	3,04	3,25	3.13	2.7	2.91
August	2,77	3,31	2.93	2.73	2.91
September	2,51	2,93	2.55	2.58	2.72
Oktober	2,43	2,51	2.23	2.45	2.61
November	2,05	2,23	2.27	1.84	2.31
Desember	2,45	2,83	3.09	2.38	1.91
Annual	2,75	2,83	2,73	2,65	2,57

CONCLUSION

Based on the results and discussion, it was found that there were several changes in the air quality indicators after the construction of the Kendal Industrial Estate (KIK) compared to conditions before the construction. There was an increase in air temperature and surface pressure which was not significant, while air humidity and the annual average wind speed decreased. This shows that the existence of the KIK caused changes in environmental conditions. However, these changes are not significant, therefore the air parameters are still within the comfort limits for industrial areas.

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