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AIR QUALITY INDEX AND THE URGENCY OF ENVIRONMENTAL EDUCATION IN KALIMANTAN

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ABSTRACT

As one of the logical consequences of the transformation process from agricultural to industrial societies, human activities contribute some pressures to our environment, especially air quality. Kalimantan Island, as the third-largest island on Earth, expected to be the world's lungs, transboundary massive haze problems frequently occurred on this island, especially between 2011-2015. Since the fire forest started from the Indonesia side of this island, reliable information about air quality in Kalimantan-Indonesia and environmental education's urgency toward this result becomes essential to explore. Air Quality Index (AQI) is measured by a passive sampling method with SO₂ dan NO_x as pollutants' parameters. These two parameters are recognized as a valid measurement of air pollutants, strongly affect human health, and are understandable by ordinary citizens, especially middle school level students. AQI reached 94.27, which is categorized as a good-quality index. Among the provinces, the highest AQI was reached by East and North Kalimantan with 97.63, while South Kalimantan has the lowest with 91.41. Furthermore, the NO_x parameter contributed much larger than SO₂ parameters in all provinces. AQI Kalimantan tends to increase, although South Kalimantan tended to have a lower air quality index than other provinces from year to year. This result drives comprehensive support from the education sector to build environmental understanding. From an educational perspective, this result shows the urgency of enhancing science education with air quality discussion. We suggest a possible enhancement in substance and its transformation section and the Science-Environment-Technology-Society section in Science for Junior and Senior High School. The procedure of AQI measurement and the urgency of maintaining AQI are needed to be integrated into the science curriculum.

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Keywords: air quality; environmental education; Kalimantan

INTRODUCTION

The concept of air quality is strongly related to the discussion of the air pollution issue. In severe condition, air quality problem was reported to kill more people worldwide than AIDS, malaria, breast cancer or tuberculosis (Rohde & Muller, 2015; Lim et al., 2012; Yang et al., 2013). This notion made air quality become a critical issue in environmental problems in the world

(Annesi-Maesano, 2017; Rohde & Muller, 2015). In developing countries' situations, the air pollution issue has reached a crisis point (Haryanto & Franklin, 2011). However, most of the research only focused on the measurement of air pollution (Cheewaphongphan & Garivait, 2013; Masiol et al., 2014; Monteiro et al., 2017; Rohde & Muller, 2015) but rarely aligned the result with the possible support from educational sectors.

The problem of air quality is transboundary, especially on an island that is shared among several countries, such as Kalimantan. As the

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third-largest island on Earth expected to be the lungs of the world, transboundary massive haze problems frequently occurred on Kalimantan Island, especially between 2011 - 2015. The discussion about air quality will be related to the climate change issue. In Indonesia, the climate change issue receiving much attention since this country being the world's third-largest emitter of greenhouse gases (Measey, 2010). The implications of climate change are massively affected by how people manage their life because it can cause several problems that come along with corresponding social and economic crises, including increased risks of drought, flooding, landslides, fires, and disease (Mimura, 2013). Since Kalimantan is one of the world's lungs because of its largest forest area, the problems in this area will affect the country and widely in the world. In 2015, the Indonesia government was considered slow to tackle this issue, and this problem was widespread to its neighbor, such as Malaysia and Singapore (Soh & Peh, 2016). In this duration of time, Kalimantan island became one of the crucial factors of the southeast Asia haze problem (Ewing & McRae, 2012; Lee et al., 2016; Purnomo et al., 2018; Sunchindah, 2015). Therefore, the period from 2011 to 2015 became a critical period to explore more detail.

Exploring the relationship between air pollution with school-age students has been discussed in several studies. From the epidemiological perspective, air pollution has significant impacts on mortality and cardiovascular and respiratory diseases (Quarmby et al., 2019). Exposing students with polluted air has been proven to bring a serious problem on their health and academic performance in the U.S. and Chile (Miller & Vela, 2013; Mohai et al., 2011). Because the mining areas are spread all over the island of Kalimantan, many schools are located near this area. Our preliminary observation in SMP (Junior High School) 33 Samarinda, East Kalimantan and SDN (Elementary School) Lamida Atas, Banjarmasin, West Kalimantan showed that the mining area too close to the education facilities. This situation is dangerous for the children because they exhale low quality of air for years. Therefore, preparing young citizens of Kalimantan Island to understand the dynamics of air quality is necessary.

In line with the urgency of maintaining air quality, support from society is essential. This awareness needs to be built since childhood, and formal education plays a crucial role. Effective

environmental education represents more than a unidirectional transfer of information but also undertake positive environmental attitude and action (Ardoin et al., 2020; Erhabor & Don, 2016). This issue in Indonesia is identified as a crucial challenge within the country and globally (Parker & Prabawa-Sear, 2019; Yustina et al., 2020). However, environmental education is not considered a priority yet in Indonesia educational system. Until now, the environmental education curriculum still cannot be found explicitly in the body of the formal education curriculum (Prihantoro, 2015; Ruka et al., 2018). In well-developed countries like the USA or Japan (Fasolya, 2016; Kodama, 2017), environmental education is remarkably arranged both in formal and informal education sectors. In Indonesia, this issue becomes part of science education. Therefore the urgency of this issue tends to be neglected.

On the other hand, integrating real environmental problems recognized as one of the keys to the successful science learning process (Afriana et al., 2016; Cahyaningsih & Roektingroem, 2018; Marshall & Harron, 2018; Rillero et al., 2018). Therefore, we urge that the connection of the air quality index in Indonesia with the environmental education part is beneficial to bridge the condition. However, a few studies have been done before to deeply explore in which part of the science education curriculum, the issue of environment could be integrated. Therefore, our research aims to measure the air quality index (from 2011 to 2015) through understandable and valid measurements on some locations on Kalimantan and align the procedure and result with possible integration in Indonesia's science curriculum.

METHODS

Figure 1 shows the research methodology of this research. This research used a mixed-method between quantitative and qualitative methods. The measurement of air quality index (AQI) and its trend parts was analyzed by the quantitative method, and the environmental education parts were analyzed by the document analysis of the qualitative method. Numerical data in this article were secondary data that were gathered mainly from the Center of Data and Information Ministry of Health Republic of Indonesia in cooperation with The Centre of Ecoregion Development Control (P3E) Kalimantan Ecoregion in 2015. Within 2016 - 2017, the tabulation and analysis were conducted.

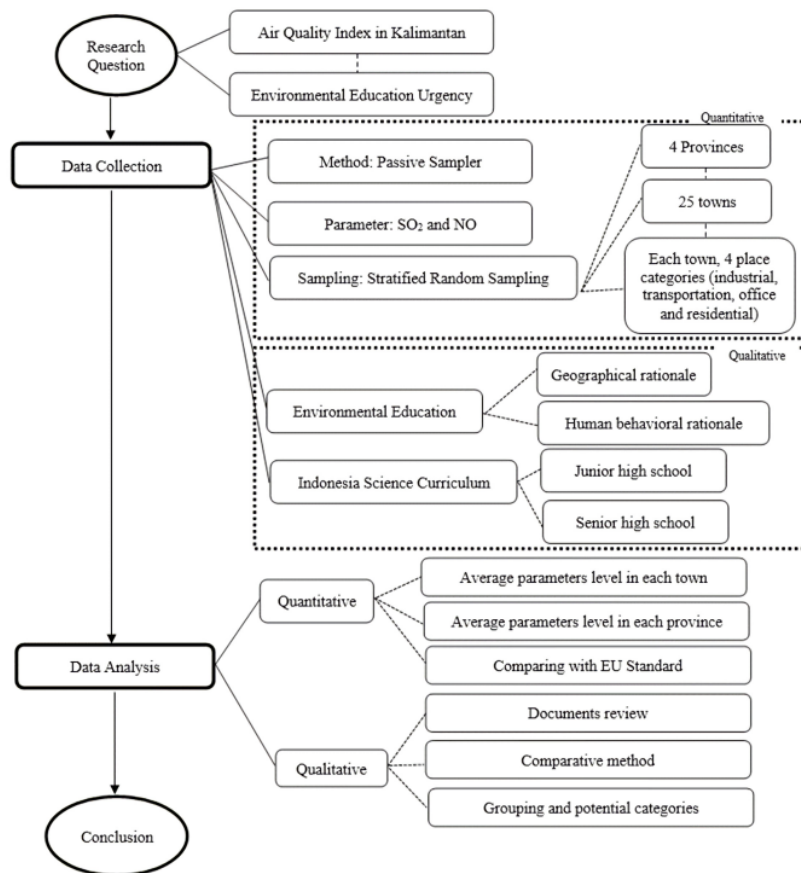


Figure 1. Research Methodology

SO₂ and NO₂ chosen as the parameter in this research because both of these parameters are the most monitored pollutants in ambient air and of their effects on the human respiratory system, their contributions to the acidification of the ecosystems and their roles in the formation of photochemical oxidants (Ghozikali et al., 2015; Kim et al., 2013; Masiol et al., 2014). Therefore, these parameters are essential.

The quality of the environment at the national level in Indonesia, as measured by the Environmental Quality Index (EQI) (Purnamadewi et al., 2019). The air factor is one of the crucial aspects of environmental quality and contributes to 30 % of province EQI. The data was measured by the passive sampler method. This method was chosen because it is manageable, low-cost, no input energy requirement, and a useful tool in detecting atmospheric metals, such as CO (Khu-

riganova et al., 2019; McGrath & Scanaill, 2013; Salim & Górecki, 2019). This method is based on the principle of pollutant passive diffusion through an air layer to an absorbing medium. This research was conducted all over Kalimantan island consisting of 5 provinces. From the five provinces, the provinces were only grouped into four, which are West Kalimantan Province, Central Kalimantan, South Kalimantan, and East Kalimantan, along with North Kalimantan, whereas represented by 25 towns as sample points. East Kalimantan and North Kalimantan provinces were combined into one analytical group because the area of North Kalimantan has been once part of the East Kalimantan region. Each town/district measurements were conducted in four location categories representing industrial, transportation, office, and residential sources. One sample was collected for each category in each lo-

cation. All the formulas followed the adaptation from Indonesia government through the Ministry of Environment and Forestry (MNLKH, 2018)

The following equation calculated the mean values of SO₂ or NO₂ in a sampling location:

$$a = \frac{a_1 + a_2 + a_n}{n}$$

For additional information, *a* is the mean value of SO₂ or NO₂ concentration (µg/Nm³) in a sampling location. This formula is applied to all other sampling locations (e.g., *a*, *b*, *c*, and *d*, are the mean values of SO₂ or NO₂ at 1, 2, 3, and 4 sampling locations). The air quality indexes calculation was done by comparing the annual mean values to the European Union (EU) standard. The EU standards are overpassed by one or both pollutants if the index is > 1. Otherwise, the air quality meets the standards if the index is ≤ 1. The air index EU model (*I_{eu}*) was calculated by using 20 µg/Nm³ and 40 µg/Nm³ are the quality standards (target values) of SO₂ and NO₂, respectively. More than these limits are recognized as harmful to humans.

$$I_{eu} = \frac{\left(\frac{p_1}{20}\right) + \left(\frac{p_2}{40}\right)}{2}$$

The *I_{eu}* value was then converted into the AQI using the following equation:

$$AQI = 100 - \left(\frac{50}{0.9} \times (I_{eu} - 0.1)\right)$$

The calculated AQI is based on the assumption that air quality data are pollutant concentration data. Hence it needs to be converted into air quality concentration by subtracting 100 percent by the pollutant concentration data. The index value that describes the air quality of a region is the maximum value of the index of all parameters at all monitoring locations in the region (EEA, 2018). The EQI criteria with the scale range of 0-100 were used for the categorization of the air quality based on calculated AQI. The EQI criteria are shown in Table 1.

Table 1. Environmental Quality Index (EQI) Criteria for the Air Quality Categorization

| Index | EQI criteria |
|---------------------|--------------|
| $x > 90$ | Superior |
| $82 < x \leq 90$ | Very Good |
| $74 < x \leq 82$ | Good |
| $66 \leq x \leq 74$ | Fair |
| $58 \leq x < 66$ | Poor |
| $50 \leq x < 58$ | Very poor |
| $x < 50$ | Warning |

Considering the area of Kalimantan island in Indonesia (around 550 thousand km²), it is our biggest challenge to collect the air quality data from a sufficient area of sampling. From 4 provinces, 25 places were chosen as the samples by considering four categories (industrial, transportation, office, and residential area). The forest area is neglected due to the minimum transportation infrastructure to reach that area. Another limitation of a wide area of sampling was the limitation of air pollutants that could be measured. From various air pollutants that were recognized, we measured only SO₂ and NO₂. These two parameters are recognized as a valid measurement of air pollutants, strongly effect on human health and have a high possibility to be understood by ordinary citizens, especially middle school level students.

For the qualitative data, the AQI result, former research about environmental education such as the general definition and its urgency (Ardoin et al., 2020; Jorgenson et al., 2019; Parikesit & Withaningsih, 2018) and research in specific topics in environmental education (McGrath & Scanaill, 2013; Ruka et al., 2018; Suryawati et al., 2020) and also Indonesia science curriculum for junior and senior high school, were analyzed. Firstly, these documents were selected and labeled to identify meaningful and relevant parts of the documents (Suri, 2020). Then the documents identified through the first process were justified as the urgency of environmental education in Kalimantan. Moreover, analysis of the science curriculum in Indonesia was carried out to outline the potential topics that possibly strengthen environmental education in Kalimantan, especially in air quality issues. The relationship degree is based on the curriculum compatibility with AQI, which ranges from 1 to 5 (1 for address weekly and 5 for address enormously). Two science education department lectures and two science teachers were involved in a group discussion to rate the compatibility.

RESULTS AND DISCUSSION

In this section, the quantitative results were presented and followed by the qualitative results. For the quantitative data, the result of AQI measurements is presented based on several divisions that facilitated a deeper understanding of its trend. First, the general result of AQI in Kalimantan is performed, and the details of each province's situation were provided. In the context of our study, the AQI was monitored by two parameters. Therefore, the result of NO₂ and SO₂ levels are discussed for each province.

Moreover, the details of AQI for all sampling districts were presented. Elaboration of our result with the earlier results was discussed to understand the more significant trend. As a continuation of the quantitative result, the qualitative data were explicitly discussed to explore the possible integration of those result in environmental education. The exploration was conducted through the rationale from the geographical and human behavioral perspectives then elaborate on

the earlier results to the possible integration in the science curriculum.

General Result of the Air Quality Index in Kalimantan

The AQI Kalimantan in 2015 reached 94.27, which is categorized as a superior quality index. This number is an average of AQI in each province in Kalimantan. The values of AQI obtained are shown in Figure 2.

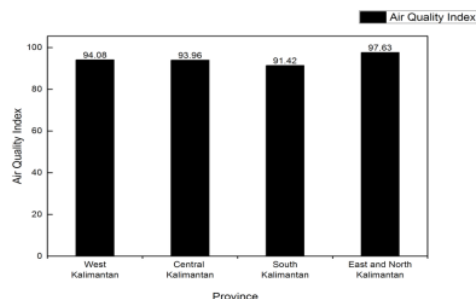


Figure 2. Air quality Index each Province in Kalimantan

AQI values in the figure were derived from the average value of the air quality index from several sample points located in each province. Among the provinces, the highest AQI reached by East and North Kalimantan with 97.63 while South Kalimantan had the lowest AQI with 91.41. The results in the tropical area tend to be more consistent due to the climate stability compared to subtropical such as China and Iran area that showed the effect of season on their AQI result (Heidarinejad et al., 2018; Ikram et al., 2015; Xu et al., 2019) the spatiotemporal patterns of AQI in North China were investigated, then the influence of meteorological and socio-economic

factors on AQI was discussed by statistical analysis and ESDA-GWR (exploratory spatial data analysis-geographically weighted regression). Therefore, our result in Kalimantan was consistent throughout the season fluctuation.

Moreover, the NO_2 parameter contributed much larger than SO_2 parameters in all provinces in Kalimantan (Figure 3). The highest concentration value was measured in the South Kalimantan province, with $5.13 \mu\text{g}/\text{Nm}^3$ of SO_2 and $10.1 \mu\text{g}/\text{Nm}^3$ of NO_2 . The maximum level for SO_2 is $20 \mu\text{g}/\text{Nm}^3$ and NO_2 is $40 \mu\text{g}/\text{Nm}^3$ (EEA, 2018; Purnamadewi et al., 2019). More than these limits are recognized as harmful to humans.

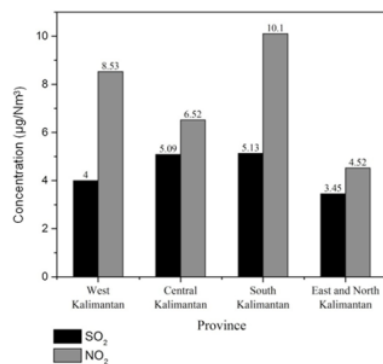


Figure 3. Comparison of SO_2 and NO_2 Concentrations per Province

The contribution of the location categories to the pollutants' concentration is shown in Figure 4. Residential was the category that most contributed to the SO_2 concentration in West and Central Kalimantan, while transportation and office areas were the most contributors of SO_2 concentration in South and East/North Kalimantan, respectively. The transportation area was

the highest contributor for NO_2 concentration for all provinces, except East and North Kalimantan. In general, transportation sectors gave the most influence on the emission, especially South Kalimantan. Rapid urbanization in Kalimantan generates deterioration in the quality of the environment (Subagiyo et al., 2019; Forina et al., 2018).

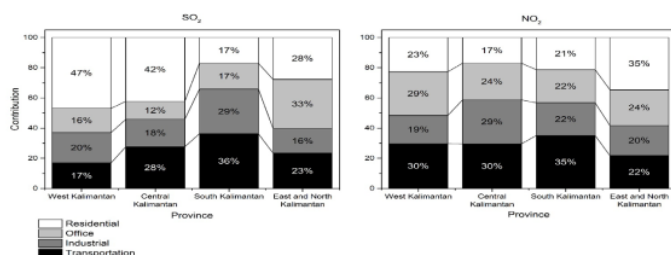


Figure 4. Contribution of Location Categories to the Concentration of SO_2 and NO_2

The high number of motor vehicles that dispose of burning emissions into the air dramatically influences the high value of SO_2 and NO_2 parameters (Kobza & Geremek, 2017; Krotkov et al., 2016) it is necessary to control the levels of air pollution near road exposure. The primary air pollutants emitted by motor vehicles are CO , NO_2 . Fuel oil dominates the use of energy for the transportation sector. The growth of motorcycle number brings adverse effects to environmental conditions such as road congestion, emission to the air, ambient air quality improvement. In 2014, South Kalimantan had approximately 2.143.380 units of vehicles compare with East and North Kalimantan with 2.490.341 units (Effendi et al., 2015). Since South Kalimantan is smaller in area, so the density of vehicles is more significant than in East and North Kalimantan. Fuel consumption increases according to the number of vehicles that increased annually.

Along with the increase in vehicles and fuel consumption, the amount of NO_2 and CO_2 emissions generated also increased. Consequently, the contribution of the transportation sector to the NO_2 pollution was high (Figure 4). Another factor that strongly influences AQI in Kalimantan ecoregion was the forest fire problem. In particular tropical Asia, several studies have revealed significant biomass burning emissions from deforestation, slash and burn grassland (Engling et al., 2014), agricultural residue burning (Cheewaphongphan & Garivait, 2013; Vadrevu et al., 2012; Vadrevu & Justice, 2011), forest and land fire for palm plantations and peatland burning (Purnomo et al., 2018). Indonesia's government is still trying to reduce this problem.

In 2015, Indonesia experienced one of its most destructive fire seasons. Haze sources were mainly forest and peat fires associated with aggressive human activities with a very high deforestation rate of nearly 2% per year (ca. 15,000 km^2 /year) (Alisjahbana & Busch, 2017; Hayasaka et al., 2014). South Kalimantan lost 1,714.89 ha of forest area due to forest fires (Endrawati, 2016). The total area of South Kalimantan was 38,744 ha, so that about 4.5% of this area was burned (Kennedy, 2018). Compared to the province of West Kalimantan with an area of 147,307 ha, forest fires covering an area of 3,191.98 ha, it can be concluded that West Kalimantan lost only 2.1% of the forest area. The loss of 4.5% of the forest area contributed to the low value of AQI South Kalimantan among other provinces in Kalimantan. This situation had a significant impact on the air quality of South Kalimantan province, which has the lowest quality among the four provinces in the Kalimantan ecoregion.

The variations of AQI in 25 districts/towns taken as sampling in this study can be seen in Figure 5. In contrast with the result that revealed South Kalimantan had the lowest AQI, the highest AQI was reached by a district in this province, which is Tanah Bumbu (99.92). This fact reveals that the situation in South Kalimantan province was quite heterogeneous because the highest and the lowest AQI were found in this province. The location that had the lowest AQI was reached by the Banjar district, with only 82.08 but still categorized as very good quality.

Kalimantan population growth automatically increases the need for food and energy factors. Based on data sourced from the Central

Bureau of Statistics 2015, the population of Kalimantan is around 12 million people, and this number continued to increase significantly from the population in the previous year (Putri, 2019; Effendi et al., 2015). Consequently, the efforts to meet people's needs lead to the exploitation of natural resources such as forests, minerals, and natural gas oil. Among the province, South Kalimantan is the most populated area. In compa-

ison with East Kalimantan, the population in the West area is four times bigger in 2015 (Putri, 2019; Effendi et al., 2015). This process caused natural resources reduction and environmental degradation. A further consequence of degradation was the decline in the ability of the environment to provide healthy air for Kalimantan citizens, especially in the West area.

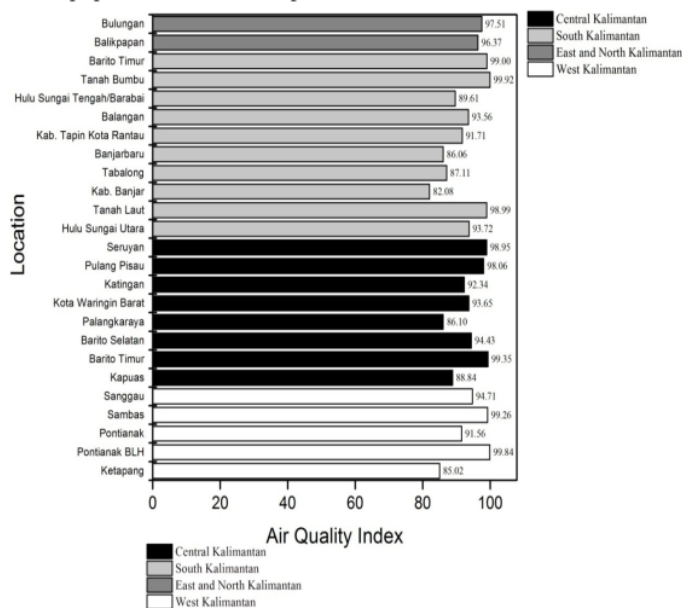


Figure 5. Air Quality Index Each Sampling Location

From the data in Figure 5, it can be observed that the district of Banjar in South Kalimantan province had the lowest air quality from all monitoring points. The air quality index in Banjar district was 82.08. This index was possibly the result of the smog triggered by land and forest fires that covering almost the entire province (Hadi, 2016; Tacconi, 2016; Arini et al., 2020). Based on the observation in this area, low air quality was almost evenly distributed throughout Banjar Regency because smoke haze enveloped the entire area unhindered by space. The naked eye could see even the poor quality of air because almost every day shrouded in haze, especially early morning until late afternoon.

Air Quality of the Kalimantan Ecoregion

Air quality is one of the environmental quality index indicators. In general, AQI in Kalimantan Ecoregion was categorized as superior quality in 2015 and cannot be separated from

the existence of forests in this Ecoregion. If we compare AQI in the Kalimantan ecoregion within the last five years, the trend fluctuated from 2011 to 2014, and increased significantly in 2015, as shown in Figure 6. All provinces within the Kalimantan ecoregion experienced an increase in the trend of AQI. However, it increased most significantly in the province of East Kalimantan. This result is related to the exploitation activity of coal mining associated with the provincial government's policy on mining exploitation permits and reclamation efforts. In 2015, East Kalimantan closed the operations of 10 coal mining companies that abandoned mining pits without any reclamation efforts, thus threatening the lives of the people. Another effort supporting the upward trend in AQI was revegetation in some areas of the Kalimantan ecoregion that has begun to succeed. Besides, the initiation of some places industrial forest plantations has been quite successful.

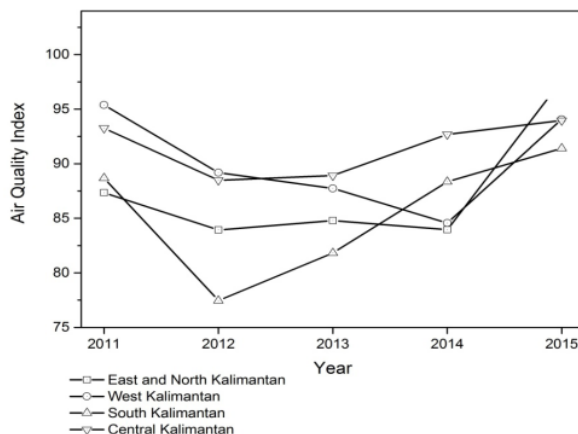


Figure 6. Trend of Air Quality Index in Kalimantan Ecoregion (2011-2015)

In contrast with the situation in East Kalimantan, Figure 6 informs that South Kalimantan Province tended to have a lower air quality index than other provinces every year and had the lowest AQI around below 80 in 2012. However, efforts to maintain air quality showed a significant increase until 2015. Although compared to other provinces in Kalimantan ecoregion, the province of South Kalimantan was still the province with the lowest air quality index.

The Urgency of Environmental Education in Kalimantan

From our result in Figure 4, residential and transportation categories became the most significant contributors to air pollutants. These factors emphasize the importance of increasing citizen understanding and environmental awareness, mostly related to air quality. As an important starting point, we argue that the science lesson in the formal education level suitable to bridge this issue. In this section, we discuss the urgency of environmental education in Kalimantan from several rationales, which are geographical rationale, human behavior rationale, and the possible integration in the science curriculum.

Geographical Rationale

According to the United Nations Office for Disaster Risk Reduction (UNISDR), Indonesia is one of the most disaster-prone countries because of its geographical location (Stanton-Geddes & Van, 2019). This country is one of the most vulnerable countries to forest fire, earthquakes, tsunami, floods, volcanoes, droughts, and other kinds of disasters. As an archipelago country, challenges also appear from transportation issues

among the islands. Moreover, a massive population of Indonesia makes a higher challenge for the education sector.

In Kalimantan's case, besides the geographical factors, the high rate of forest fire makes environmental education in this area massively important. The urge for environmental education becomes an inseparable part of the quality of the environment. In many cases, the root of the environmental problem is related to social and cultural issues because most people have economic needs related to natural sources (Teksoz, 2011). In Kalimantan's situation, oil and coal have become significant economic support for many people. Therefore, the impact in the environment has to arrange hand in hand with this need. Introduction to the non-renewable energy source and alternative energy source needs to be explored.

In the beginning, before education becomes somehow standardized, education is strongly related to the way people understand their closest environmental situation. Nowadays, this notion is well known for place-based education (Surface, 2016). This relation is influential for bridging the real-life condition with the learning process, especially at school (Rillero et al., 2018). Therefore, the geographical rationale has a positive contribution to the future lives of students. This idea is also in line with the worldwide education movement called Science-Technology-Engineering-Mathematics (STEM) education (Jang, 2016; Roberts, 2013) that emphasizes the importance of real-life problems (Marshall & Harron, 2018) that enhance students interest in learning (Krajcik & Delen, 2017). From the result of AQI, the situation in South Kalimantan seems the most vulnerable area. Environmental education in this

area needs serious attention from the society that could be built through education sector.

Human Behavioral Rationale

In the beginning, environmental problems were often seen as scientific problems like we discussed earlier that geographical factor makes Indonesia dealing with disaster. Moreover, even the scientists themselves were arguing that science and technology were not enough. Human behavior becomes one of the crucial keys when the discussion about the environment arises. One of the powerful tools to maintain the environment is through education (Karataş & Karataş, 2016). Sufficient knowledge about natural disasters and disaster management should be taught in Physics and Geography subjects at schools (Ansori et al., 2013). Environmental education can be built by formal and informal education sectors (Furihata & Ninomiya-Lim, 2017). Through formal education, the discussion about air quality needs to be emphasized in every education level. A comprehensive discussion about air could be built in science learning. For the Kalimantan case, the discussion about SO₂ and the source of it needs to be studied. The reason is this pollutant gave the most significant impact on the air quality in this island. In the West Kalimantan case, the discussion about their air quality that always tends to be the lowest in the island needs to be done in science and social lesson. The results of this rese-

arch about trend of AQI (Figure 6) can be used as discussion material. Then depending on the level of education, students could give their opinion and possible solution to this issue.

Possible Integration in Science Lesson

Since environmental education related to air quality is urgent, the discussion about the potential topic in the Indonesia science curriculum is needed. The aim of environmental education is maintaining equilibrium between quality of life and the environment and the need to maintain sustainable relations (Keles, 2012; Justice, 2019). Moreover, contextual teaching and learning could develop critical thinking (Tari & Rosana, 2019) and learning outcome (Lotulung et al., 2018). For the students in Kalimantan ecoregion, they will deal with many decisions in their life that relate to this issue. In the Kalimantan context, a typical example is the land clearing in forest areas by burning the trees. The students live with this issue as part of their daily life.

Based on the AQI result, we emphasized three significant issues about the pollutant, the trend of AQI, and the low AQI in South Kalimantan. Junior and Senior High School levels were chosen by considering the complexity of the air quality concept. On the other side, from the curriculum review, six topics are identified as significant standards for science education at the high school level (Figure 7).

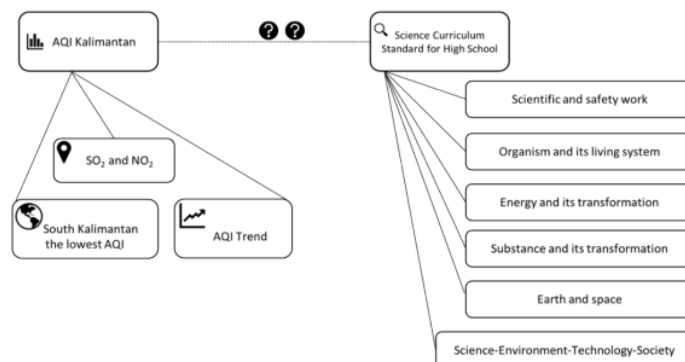


Figure 7. Relation between AQI Result with Science Curriculum

The rate of compatibility analyzed the AQI result and the topics in the science curriculum. From the document analysis, we addressed **only two main topics related, which were substance and its transformation, and Science-**

Environment-Technology-Society meanwhile, the other topic could provide secondary support (Table 2). The precise development of learning material in these topics becomes potential research in the future.

Table 2. Potential Topic in the Science Curriculum

| No | Topic | Ad-dressed Strongly | Potential part | |
|----|--|---------------------|---|---|
| | | | Junior high school | Senior high school |
| 1 | Scientific and safety work | 1 | Introduction to basic measurements tools | Logical thinking about air quality |
| 2 | Organism and its living system | 3 | Effect of air quality on plants and aquatic organisms | Importance of air quality for the organism Effect of air quality on molecules, cells, tissues, organs, and many more. |
| 3 | Energy and its transformation | 3 | Energy source and eco-friendly source of energy | Energy sources and eco-friendly digital technology Thermodynamics law |
| 4 | Substance and its transformation | 5 | Introduction of SO ₂ and NO elements Physical and chemical changes involving SO ₂ and NO | Composition, structure, and properties of SO ₂ and NO SO ₂ and NO reactions with other substances/ compounds The formation of acid rain due to the influence of SO ₂ |
| 5 | Earth and space | 4 | Introduction about the weather and human activities that affect it | Hydrology cycle Earth as a system Forest fire phenomenon around Kalimantan |
| 6 | Science-Environment-Technology-Society | 5 | Global warming in Kalimantan area | Global warming and its implication to Kalimantan island |

CONCLUSION

The results showed that the AQI of Kalimantan in 2015 reached 94.27, which was categorized as superior quality. Among the provinces, East and North Kalimantan reached the highest AQI with 97.63, while South Kalimantan had the lowest AQI with 91.41. Furthermore, the NO₂ parameter contributed much larger than SO₂ parameters. During 2011-2015, AQI Kalimantan tended to increase, although South Kalimantan tended to have a lower air quality index than other provinces every year. This condition was mainly caused by the residential, transportation sector and forest fire. As the impact of this result, as general Kalimantan ecoregion needs to maintain the positive trend of AQI and specifically for South Kalimantan, that needs serious approaches to deal with low AQI.

From the quantitative result, the most significant contributors for air pollutants are residential and transportation categories, which signify the education about good management of settlements and transportations are necessary for maintaining air quality. Moreover, the positive

overall trend and the situation in South Kalimantan show the urgency of building an understanding from Kalimantan citizens about air quality. From our analysis to the science curriculum for Junior and Senior High School levels, discussion about air quality could be enhanced in two major sections, which are substance and its transformation section and Science-Environment-Technology-Society section. The procedure of AQI measurement and the urgency of maintaining AQI are needed to be integrated into the science curriculum.

REFERENCES

- Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project-based learning integrated to stem to enhance elementary school's students' scientific literacy. *Jurnal Pendidikan IPA Indonesia*, 5(2), 261-267.
- Alisjahbana, A. S., & Busch, J. M. (2017). Forestry, forest fires, and climate change in Indonesia. *Bulletin of Indonesian Economic Studies*, 53(2), 111-136.
- Annesi-Maesano, I. (2017). The air of Europe: where are we going?. *European Respiratory Review*, 26(146), 1-5.

- Ansori, I., Ramalis, T. R., & Utama, J. A. (2013). Analisis Kurikulum Ilmu Pengetahuan Bumi Dan Antariksa Pada Jenjang Sekolah Menengah Atas. *WaPFI (Wahana Pendidikan Fisika)*, 1(1), 76-83.
- Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, 241, 108224.
- Arini, E. Y., Adi, R. F., Siregar, R., Clatworthy, Y., & Dewi, N. W. S. P. (2020). Meteorological Services for Forecast Based Early Actions in Indonesia. In *Handbook of Climate Services* (pp. 353-382). Springer, Cham.
- Cahyaningsih, F., & Roektinigroem, E. (2018). Pengaruh Pembelajaran IPA Berbasis STEM-PBL terhadap Keterampilan Berpikir Kritis dan Hasil Belajar Kognitif. *Pend. Ilmu Pengetahuan Alam-SI*, 7(5), 239-244.
- Cheewaphongphan, P., & Garivait, S. (2013). Bottom-up approach to estimate air pollution of rice residue open burning in Thailand. *Asia-Pacific Journal of Atmospheric Sciences*, 49(2), 139-149.
- EEA. (2018). *Air quality 2018 - EEA report 12 2018*.
- Effendi, H., Romanto, W. Y., & Wardiatno, Y. (2015). Water quality status of Ciambulawung River, Banten Province, based on pollution index and NSF-WQI. *Procedia Environmental Sciences*, 24(4), 228-237.
- Endrawati, S. H. (2016). Analisis Data Titik Panas (Hotspot) dan Areal Kebakaran Hutan dan Lahan tahun 2016. *Kementerian Lingkungan Hidup dan Kehutanan*, 1.
- Engling, G., He, J., Betha, R., & Balasubramanian, R. (2014). Assessing the regional impact of Indonesian biomass burning emissions based on organic molecular tracers and chemical mass balance modeling. *Atmospheric Chemistry and Physics*, 14(15).
- Erhabor, N. I., & Don, J. U. (2016). Impact of Environmental Education on the Knowledge and Attitude of Students towards the Environment. *International Journal of Environmental and Science Education*, 11(12), 5367-5375.
- Ewing, J. J., & McRae, E. (2012). Transboundary haze in Southeast Asia: Challenges and pathways forward. *NTS Alert*.
- Fasolya, O. (2016). The system of environmental education in the USA. *Comparative Professional Pedagogy*, 6(3), 85-90.
- Forina, N., Mahreda, E. S., Rahman, M., & Mahmud, M. (2018). Analysis of Water Quality Status Based on Domestic Waste Parameters by Using Pollutant Index Method at Tabuk River, Central Kalimantan Province. *TROPICAL WETLAND JOURNAL*, 4(1), 25-29.
- Furihata, S., & Ninomiya-Lim, S. (2017). Environmental Education in Asia: Questions and Challenges. *Japanese Journal of Environmental Education*, 26(4), 4_1-6.
- Ghozikali, M. G., Mosaferi, M., Safari, G. H., & Jaafari, J. (2015). Effect of exposure to O₃, NO₂, and SO₂ on chronic obstructive pulmonary disease hospitalizations in Tabriz, Iran. *Environmental Science and Pollution Research*, 22(4), 2817-2823.
- Hadi, A. M. (2016). *DREF Final Report Indonesia : Forest Fires*.
- Haryanto, B., & Franklin, P. (2011). Air pollution: a tale of two countries. *Reviews on environmental health*, 26(1), 53-59.
- Heidarinejad, Z., Kavosi, A., Mousapour, H., Daryabor, M. R., Radfard, M., & Abdolshahi, A. (2018). Data on evaluation of AQI for different season in Kerman, Iran, 2015. *Data in brief*, 20, 1917-1923.
- Hayasaka, H., Noguchi, I., Putra, E. I., Yulianti, N., & Vadrevu, K. (2014). Peat-fire-related air pollution in Central Kalimantan, Indonesia. *Environmental Pollution*, 195, 257-266.
- Ikram, M., Yan, Z., Liu, Y., & Qu, W. (2015). Seasonal effects of temperature fluctuations on air quality and respiratory disease: a study in Beijing. *Natural Hazards*, 79(2), 833-853.
- Jang, H. (2016). Identifying 21st century STEM competencies using workplace data. *Journal of science education and technology*, 25(2), 284-301.
- Jorgenson, S. N., Stephens, J. C., & White, B. (2019). Environmental education in transition: a critical review of recent research on climate change and energy education. *The Journal of Environmental Education*, 50(3), 160-171.
- Justice, M. (2019). Sustainable development: meaning, history, principles, pillars, and implications for. *Cogent Social Sciences*.
- Karatas, A., & Karatas, E. (2016). Environmental education as a solution tool for the prevention of water pollution. *Survey in Fisheries Sciences*, 3(1), 61-70.
- Keles, R. (2012). The quality of life and the environment. *Procedia-Social and Behavioral Sciences*, 35, 23-32.
- Kennedy, S. F. (2018). Indonesia's energy transition and its contradictions: Emerging geographies of energy and finance. *Energy research & social science*, 41, 230-237.
- Khuriganova, O. I., Obolkin, V. A., Golobokova, L. P., Bukin, Y. S., & Khodzher, T. V. (2019). Passive Sampling as a Low-Cost Method for Monitoring Air Pollutants in the Baikal Region (Eastern Siberia). *Atmosphere*, 10(8), 470.
- Kim, N. K., Kim, Y. P., Morino, Y., Kurokawa, J. I., & Ohara, T. (2013). Verification of NO_x emission inventory over South Korea using sectoral activity data and satellite observation of NO₂ vertical column densities. *Atmospheric Environment*, 77, 496-508.
- Kobza, J., & Geremek, M. (2017). Do the pollution related to high-traffic roads in urbanised areas pose a significant threat to the local population?. *Environmental monitoring and assessment*, 189(1), 33.
- Kodama, T. (2017). Environmental education in formal education in Japan. *Japanese Journal of En-*

- vironmental Education*, 26(4), 4_21-26.
- Krajcik, J., & Delen, I. (2017). Engaging learners in STEM education. *Eesti Haridusteaduste Ajakiri. Estonian Journal of Education*, 5(1), 35-58.
- Krotkov, N. A., McLinden, C. A., Li, C., Lamsal, L. N., Celarier, E. A., Marchenko, S. V., ... & Boersma, K. F. (2016). Aura OMI observations of regional SO₂ and NO₂ pollution changes from 2005 to 2015. *Atmospheric Chemistry and Physics*, 16(7), 4605.
- Lee, J. S. H., Jaafar, Z., Tan, A. K. J., Carrasco, L. R., Ewing, J. J., Bickford, D. P., ... & Koh, L. P. (2016). Toward clearer skies: Challenges in regulating transboundary haze in Southeast Asia. *Environmental Science & Policy*, 55, 87-95.
- Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., ... & Aryee, M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, 380(9859), 2224-2260.
- Lotulung, C. F., Ibrahim, N., & Tumurang, H. (2018). Effectiveness of Learning Method Contextual Teaching Learning (CTL) for Increasing Learning Outcomes of Entrepreneurship Education. *Turkish Online Journal of Educational Technology-TOJET*, 17(3), 37-46.
- Marshall, J. A., & Harron, J. R. (2018). Making learners: A framework for evaluating making in STEM education. *Interdisciplinary Journal of Problem-Based Learning*, 12(2), 1-13.
- Masiol, M., Agostinelli, C., Formenton, G., Tarabotti, E., & Pavoni, B. (2014). Thirteen years of air pollution hourly monitoring in a large city: potential sources, trends, cycles and effects of car-free days. *Science of the Total Environment*, 494, 84-96.
- McGrath, M. J., & Scanail, C. N. (2013). Sensing and sensor fundamentals. In *Sensor Technologies* (pp. 15-50). Apress, Berkeley, CA.
- Measey, M. (2010). Indonesia: a vulnerable country in the face of climate change. *Global Majority E-Journal*, 1(1), 31-45.
- Miller, S., & Vela, M. (2013). The effects of air pollution on educational outcomes: evidence from Chile.
- Mimura, N. (2013). Sea-level rise caused by climate change and its implications for society. *Proceedings of the Japan Academy, Series B*, 89(7), 281-301.
- MNLKH. (2018). *Indeks Kualitas Lingkungan Hidup Indonesia 2017*. Jakarta: Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia.
- Mohai, P., Kweon, B. S., Lee, S., & Ard, K. (2011). Air pollution around schools is linked to poorer student health and academic performance. *Health Affairs*, 30(5), 852-862.
- Monteiro, A., Vieira, M., Gama, C., & Miranda, A. I. (2017). Towards an improved air quality index. *Air Quality, Atmosphere & Health*, 10(4), 447-455.
- Parikesit & Withaningsih, S. (2018, October). The need for sustainability science education in Indonesia. In *AIP Conference Proceedings* (Vol. 2019, No. 1, p. 030010). AIP Publishing LLC.
- Parker, L., & Prabawa-Sear, K. (2019). *Environmental Education in Indonesia: Creating Responsible Citizens in the Global South?*. Routledge.
- Prihantoro, C. R. (2015). The perspective of curriculum in Indonesia on environmental education. *International Journal of Research Studies in Education*, 4(1), 77-83.
- Purnamadewi, Y. L., Orchidea, M. D., & Mulatsih, S. (2019, December). Fiscal policy and environmental quality in Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 399, No. 1, p. 012051). IOP Publishing.
- Purnomo, H., Okarda, B., Dewayani, A. A., Ali, M., Achdiawan, R., Kartodihardjo, H., ... & Juniwati, K. S. (2018). Reducing forest and land fires through good palm oil value chain governance. *Forest policy and economics*, 91, 94-106.
- Putri, R. F., Naufal, M., Nandini, M., Dwiputra, D. S., Wibirama, S., & Sumantyo, J. T. S. (2019, April). The Impact of Population Pressure on Agricultural Land towards Food Sufficiency (Case in West Kalimantan Province, Indonesia). In *IOP Conference Series: Earth and Environmental Science* (Vol. 256, No. 1, p. 012050). IOP Publishing.
- Quarmby, S., Santos, G., & Mathias, M. (2019). Air quality strategies and technologies: A rapid review of the international evidence. *Sustainability*, 11(10), 2757.
- Rillero, P., Thibault, M., Merritt, J., & Jimenez-Silva, M. (2018). Bears in a boat: Science content and language development through a problem-based learning experience. *Science Activities*, 55(1-2), 28-33.
- Roberts, A. (2013). STEM is here. Now what?. *Technology and Engineering Teacher*, 73(1), 22.
- Rohde, R. A., & Muller, R. A. (2015). Air pollution in China: mapping of concentrations and sources. *PloS one*, 10(8), e0135749.
- Ruka, S., Rumiko, K., Akiko, T., & Tantut, S. (2018). Required environmental education in junior high school for pro-environmental behavior in Indonesia: a perspective on parents' household sanitation situations and teachers' awareness of environmental education. *Journal of Wellness and Health Care*, 41(1), 61-69.
- Salim, F., & Górecki, T. (2019). Theory and modelling approaches to passive sampling. *Environmental Science: Processes & Impacts*, 21(10), 1618-1641.
- Soh, M. C., & Peh, K. S. H. (2016). Indonesia's forest fires: igniting tensions in Southeast Asia. *RUSI Newsbrief*, 3, 24-2.
- Stanton-Geddes, Z., & Vun, Y. J. (2019). Strengthening the Disaster Resilience of Indonesian Cities.

- Subagiyo, L., Nuryadin, A., Sulaeman, N. F., & Widyastuti, R. (2019). Water Quality Status of Kalimantan Water Bodies Based on The Pollution Index. *Pollution Research*, 38(3), 536-543.
- Sunchindah, A. (2015). *Transboundary haze pollution problem in Southeast Asia: Reframing ASEAN's response* (No. DP-2015-82).
- Surface, J. L. (2016). Place-based Learning: instilling a sense of wonder.
- Suri, H. (2020). Ethical Considerations of Conducting Systematic Reviews in Educational Research. *Systematic Reviews in Educational Research*, 41.
- Suryawati, E., Suzanti, F., Zulfarina, Z., Putriana, A. R., & Febrianti, L. (2020). The Implementation of Local Environmental Problem-Based Learning Student Worksheets to Strengthen Environmental Literacy. *Jurnal Pendidikan IPA Indonesia*, 9(2), 169-178.
- Tacconi, L. (2016). Preventing fires and haze in Southeast Asia. *Nature Climate Change*, 6(7), 640-643.
- Tari, D. K., & Rosana, D. (2019, June). Contextual Teaching and Learning to Develop Critical Thinking and Practical Skills. In *Journal of Physics: Conference Series* (Vol. 1233, No. 1, p. 012102). IOP Publishing.
- Teksoz, G. T. (2011). Managing air pollution: how does education help?. *The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources*, 397.
- Vadrevu, K. P., Ellicott, E., Giglio, L., Badarinath, K. V. S., Vermote, E., Justice, C., & Lau, W. K. (2012). Vegetation fires in the Himalayan region—Aerosol load, black carbon emissions and smoke plume heights. *Atmospheric Environment*, 47, 241-251.
- Vadrevu, K. P., & Justice, C. O. (2011). Vegetation fires in the Asian region: satellite observational needs and priorities. *Global Environmental Research*, 15(1), 65-76.
- Xu, W., Tian, Y., Liu, Y., Zhao, B., Liu, Y., & Zhang, X. (2019). Understanding the spatial-temporal patterns and influential factors on air quality index: The case of north China. *International Journal of Environmental Research and Public Health*, 16(16), 2820.
- Yang, G., Wang, Y., Zeng, Y., Gao, G. F., Liang, X., Zhou, M., ... & Vos, T. (2013). Rapid health transition in China, 1990–2010: findings from the Global Burden of Disease Study 2010. *The Lancet*, 381(9882), 1987-2015.
- Yustina, Y., Halim, L., & Mahadi, I. (2020). The Effect of 'Fish Diversity' Book in Kampar District on the Learning Motivation and Obstacles of Kampar High School Students through Online Learning during the COVID-19 Period. *Journal of Innovation in Educational and Cultural Research*, 1(1), 7-14.

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