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Air QualityIndex and The Urgency ofEnvironmental Education in Kalimantan

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While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, transboundary massive haze problems frequently occurred on this island especially between 2011 - 2015. Since the fire forest started from Indonesia side of this island, reliable information about air quality in Kalimantan-Indonesia and the urgency of environmental education toward this result becomes essential to explore. Air Quality Index (AQI) measured by a passive sampling method with SO_2 dan NO_2 as parameters of pollutants. 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_2 parameter contributed much larger than SO_2 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 possible enhancement in Substance and its transformation section and the Science-Environment-Technology-Society section in Science for Junior and Senior High School.

Keywords: Air quality, Environmental Education, Kalimantan

Sebagaipulauketigaterbesar di dunia, Kalimantan diharapkandapatmenjadiparu-paru dunia, namunmasalahpolusi asap secaraberkalaseringterjadi di pulauinikhususnyaantara 2011-2015. Kebakaranhutanterjadi pada wilayah Indonesia daripulauini, makainformasi yang reliabelmengenaikualitasudara, trenkualitasudara dan urgensipendidikanlingkunganterkaithasilinimenjadisangatpentinguntukditeliti. IndeksKualitas Udara (IKU) diukurmenggunakanmetode passive sampling dengan parameter polutanSO_2 dan NO_2. IKU Kalimantan pada tahun 2016 adalah 94.27 yang tergolongdalamkategoribaik. Diantaraprovinsi di Kalimantan, Kalimantan timur dan utaramencapaikualitasterbaikdengan 97.63 sedangkan Kalimantan selatanhanya 91.41. KontribusipolutanNO_2lebihtinggi di semuaprovinsidibandingkanpolutan SO_2. IKU Kalimantan cenderungmeningkatnamun Kalimantan selatanselalumemilikikecendrunganlebihrendahdariprovinsi yang lain. Hasil inimendorongperlunyadukungan yang komprehensifdarisektorpendidikanuntukmembangunpemahamanlingkungankhususnyamengenaikualitasudara. Integrasiinidapatdilakukanmelaluitopik “Zat dan Wujudnya” serta “Sains-Lingkungan-Technologi-Masyarakat” pada sekolahmenengahpertama.

Keywords:Kalimantan, Kualitasudara, Pendidikan lingkungan.

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INTRODUCTION

As one of the logical consequences of the transforming process from agricultural to industrial societies, human activitiescontributesomepressurestoour environment especially air quality. Theconceptof air qualityisstronglyrelatedto the discussion of air pollution issue. In serious condition, air qualityproblem wasreported to kill more people worldwide than AIDS, malaria, breast cancer, or tuberculosis (WHO, 2012; WHO, 2014; O'Keefe,2013; Yang et al, 2013). This notion made air quality issue become a critical issue in environmental problem in the world (Annesi-Maesano, 2017, Haryanto & Franklin, 2011; Islam & Lopez, 2015).

The problem of air quality is transboundary problem especially in an island that shared among several countries, such as Kalimantan. While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, transboundary massive haze problem frequently occurred in this island especially between 2011 - 2015.The discussionabout air qualitywillbe relatedtotheclimatechangeissue. In Indonesia, theclimatechangeissuereceiving a lot ofattentionsincethiscountry 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 is able to cause several problems that come along with corresponding social and economic crises, including increased risks of drought, flooding, landslides, fires, and disease (Mimura, 2013; Brierly & Kingsford, 2009). Due to the fact that Kalimantan is one of the world's lungs because of its largest forest area, the problems in this area will affect for the country and widely in the world. In 2015, 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 crucial factor of south east Asia haze problem (Ewing & McRae, 2012; Karthik, Baikie, Mohan Dass, Huang, & Guet, 2017; Lee et al., 2016; Sunchindah, 2015). Another role of thisisland is its massive coal and oil mining that export around the world. Oil and coal mining are not only dominant in meeting the national energy needs but also caused serious environmental homework for the society. Therefore, the period between 2011 to 2015 became important interval to explore more detail.

Epidemiological research has shown that air pollution has significant impacts on mortality and cardiovascular and respiratory diseases(Quarmby, Santos, & Mathias, 2019). Exposing citizen especially children with polluted air has been proven to bring serious effect in their health in U.S. and Chile (Mohai, et al: 201; Miller: 2013). 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) LamidaAtas, Banjarmasin, West Kalimantan showed that the mining area extremely close to the education facilities. This situation is massively dangerous for the children because they exhale low quality of air for years. Therefore, preparing young citizen of Kalimantan island to understand the dynamic of air quality is necessary.

On the other hand, environmental education is not considered as a priority yet in Indonesia educational system. In well-developed counties like USA or Japan (Fasolya, 2016; Kodama, 2017), environmental education is seriously 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. Environmental situation heavily depends on human's living habits. Therefore, the urgency of environmental education especially in the air sector and related potential topics in science curriculum are important to be discussed.

METHOD

This research used a mix method between quantitative and qualitative method (Figure 1). The measurement of air quality index (AQI) and its trend part used quantitative method and qualitative method by document analysis for environmental education part. Numerical data in thisarticle were secondary data which were gatheredmainlyfrom Center of Data andInformationMinistryofHealth Republic of Indonesia in cooperationwith The Centre ofEcoregion Development Control (P3E) Kalimantan Ecoregion in 2015-2017.$SO_2$and NO_2chosen as the parameter in

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- contain urgency (importance) to research
- contain a carrying capacity in the form of supporting data and facts
- contain a preliminary study as a basis for the importance of the research conducted
- contain a GAP ANALYSIS Departing from the preliminary study, analysis of published articles formulated in the Gap analysis
GAP ANALYSIS refers to articles published in various internationally reputable journals to emphasize the novelty of research.
- clear limitation of research objectives

thisresearchbecausebothoftheseparameters are themostmonitoredpollutants in ambient air andoftheireffectsonthe human respiratorysystem,theircontributionstotheacidificationoftheecosystemsandtheirroles in theformationofphotochemicaloxidants (Masiol et al., 2014; Kim et al., 2013; Ghozikali et al., 2014).

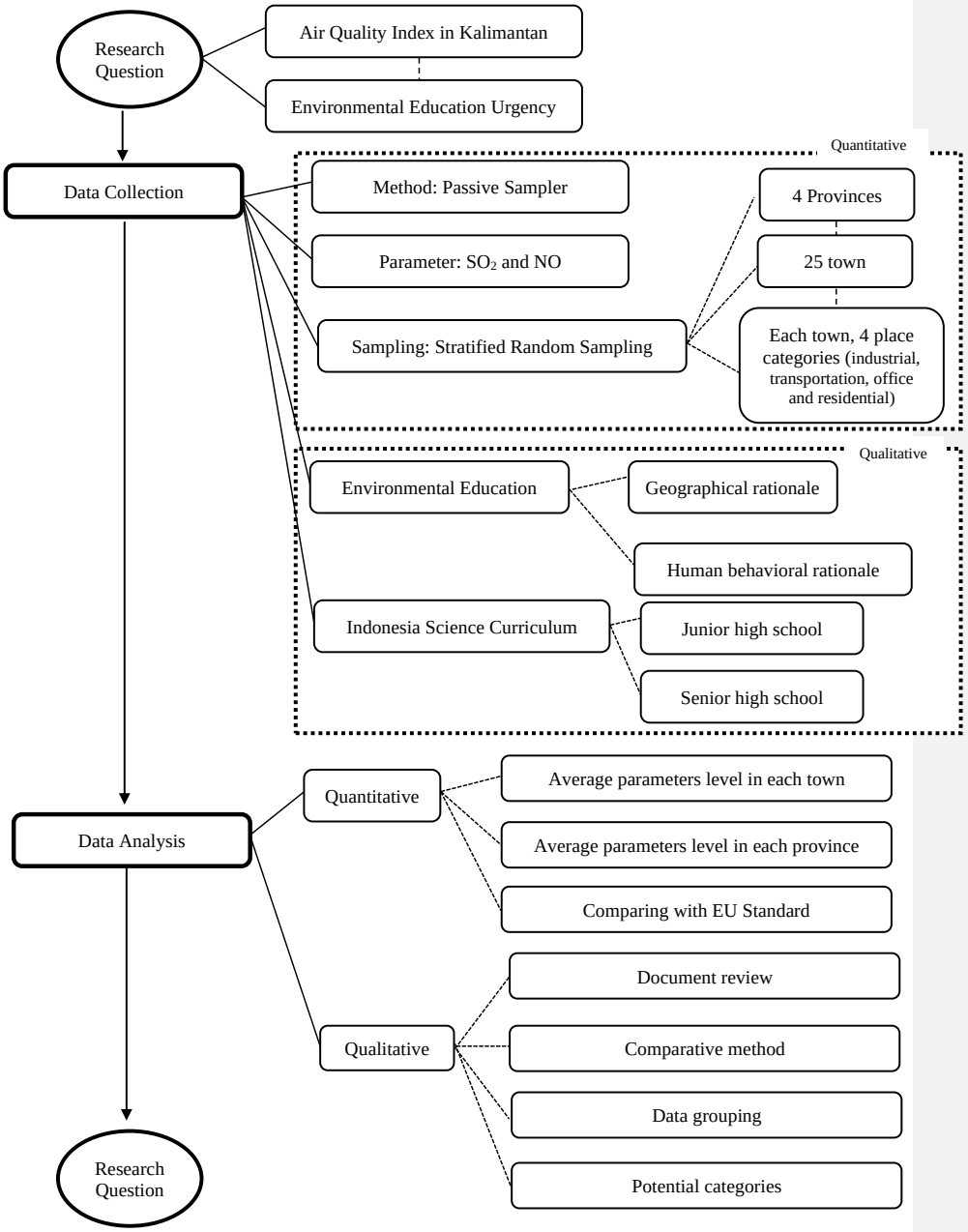

Figure 1. Research Methodology

The data was measuredbypassivesamplermethod. Thismethodwaschosenbecauseit is manageable, low-cost, no input energy requirementandan effective tool in detecting atmospheric metals, such as CO (S. Seethapathy, T. Gorecki, X. Li, 2008, Li et al., 2018).Thismethodisbasedontheprincipleofpassivediffusionof a pollutantthroughan air layer toanabsorbing medium. Thisresearchwasconductedinall over Kalimantan islandthat consistingof 5 provinces. Fromthefiveprovinces, theprovinceswereonlygroupedintofour, which areWest Kalimantan Province, Central Kalimantan, South Kalimantan,andEast Kalimantan along withNorth Kalimantan whereasrepresentedby 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.

The formula forcalculatingthe air pollutionindexis as follows:

$$a = \frac{a_1 + a_2 + a_3}{3}$$

Where:

a = Mean value of SO_2 or NO_2 in a sampling location

This formula is applied to all other sampling locations (eg a, b, c and d are the mean values of SO_2 or NO_2 at 1, 2, 3 and 4 sampling locations).

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

Where:

I_{eu} = Air Index Model EU (AIEU) or index between before normalized on index of EQI.

EU reference value has been determined and cannot be changed ie NO_2 and SO_2 parameters successively 40 and 20.

I_{eu} value is conversed in the AQI formula:

$$AQI = 100 - \left(\frac{50}{0{,}9} x (I_{eu} - 0{,}1)\right)$$

The indexvaluethatdescribesthe air qualityof a region isthemaximumvalueoftheindexofallparametersatallmonitoringlocations in the region (European Union, 2012).

For qualitative data, it is analyzed AQI result, former research about environmental education and Indonesia Science Curriculum for junior and senior high school. Firstly, these documents are selected and labeled to identify meaningful and relevant part of the documents (Bowen: 2009). Then related and needed information is identified through the first process was justified as the urgency of environmental education in Kalimantan. Moreover, analysis of science curriculum in Indonesia is held to outline the potential topics that possibly strengthen environmental education in Kalimantan, especially in air quality issue.

RESULT AND DISCUSSION

The AQI Kalimantan in 2015 reached94.27, which is categorized as a good qualityindex. This numberisanaverageofAQI in eachprovince in Kalimantan. The values of AQI obtained are shown in Figure 2. AQI values in the figure are 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 97.63while South Kalimantan has the lowest AQI with 91.41.

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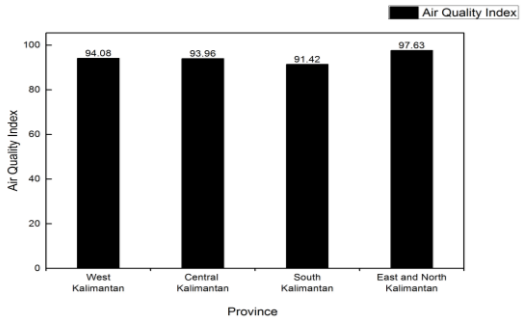

Figure 2 Air Quality Index Each Province in Kalimantan 2016

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 South Kalimantan province, $SO_2$with 5.13and NO_2 with10.1.The high value of SO_2 and NO_2 parameters was greatly influenced by the number of motor vehicles that dispose of burning emissions into the air.

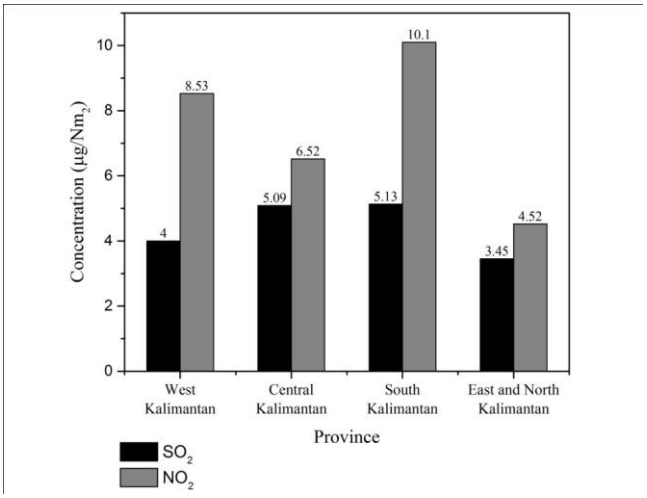

Figure3 Comparisongraphs $SO_2$and NO_2 per Province.
(Source: Pusdatin, 2015)

Transportation sectors gave the most influence on the emission. The use of energy for the transportation sector is dominated using fuel oil. The growth of motorcycle number gives negative effects to environmental conditions such as road congestion, emission to the air, ambient air quality improvement. South Kalimantan hadapproximately2.143.380 units of vehicles compare with East and North Kalimantan with 2.490.341 (Effendi, 2015). Due to the fact that South Kalimantan is smaller in area, so the density of vehicles is greater than in East and North Kalimantan.Fuel consumption increases according to the number of vehicles that increases annually. Along with the increase in vehicles and fuel consumption, the amount of NO_2 and CO_2 emissions generated also increase.

Another factor that strongly influences AQI in Kalimantan ecoregion is forest fire problem. In particular tropical Asia, several studies have revealed significant biomass burning emissions from deforestation (Werf et al., 2008), slash and burn grassland (Engling et al., 2014), agricultural residue burning (Cheewaphongphan and Garivait, 2013; Badarinath et al., 2009; Vadrevu et al., 2011, 2012), forest and land fire for palm plantations and peatland burning (Purnomo et al., 2018). Indonesia government is still trying to reduce this problem.

In 2015, Indonesia experienced one of its most destructive fire seasons to date where 4,719 points of fire were observed burning simultaneously in the peatlands and forests, emitting approximately 80 million metric tons of CO_2 during a single day (Yudha, 2016). Haze sources are 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) (Harris et al, 2015; Hayasaka et al, 2014). The Karhutla Monitoring System (2015) data showed that in 2015 South Kalimantan province lost 1,714.89 ha of forest area due to forest fires. The total area of South Kalimantan was 38,744 ha so that about 4.5% of this area was burned. Compared to the province of West Kalimantan with an area of 147,307 hectares, 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 major 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 thattaken as sampling in thisstudycanbeseen in Figure 4. In contrastwiththeresultthatrevealedSouth Kalimantan as lowest AQI,thehighest AQI wasreachedby a districtinthisprovincethatcalled Tanah Bumbu (99.92). Thisfactrevealsthatthesituation in South Kalimantan provinceisquiteheterogeneousbecausethehighestandthelowest AQI werefound in thisprovince. The location that has the lowest AQI was reached by Banjar district with only82.08.

Kalimantan population growth automatically increases the need for food and energy factors. Based on data sourced from Central Bureau of Statistics 2015, the population of Kalimantan is around 12 million people and this number continues to increase significantly from the population in the previous year (Badar, 2015; Effendi, 2015; Gultom, 2015; Sukardi, 2015). Consequently, the efforts to meet people's needs can lead to exploitation of natural resources such as forest, minerals and natural gas oil. This process will lead to the reduction of natural resources and environmental degradation. A further consequence of degradation is the decline in the ability of the environment to provide healthy air for Kalimantan people.

From the data in Figure 4, it can be observed that the district of Banjar in South Kalimantan province had the lowest air quality from all monitoring point. The air quality index in Kabupaten Banjar was 82,075. This index is the result of a mist fog triggered by forest fires and land covering almost the entire district. Poor air quality is almost evenly distributed throughout Banjar Regency because smoke haze enveloped the entire area unhindered by space. Even the poor quality of air can be seen by naked eye because almost every day shrouded in haze, especially early morning until late afternoon.

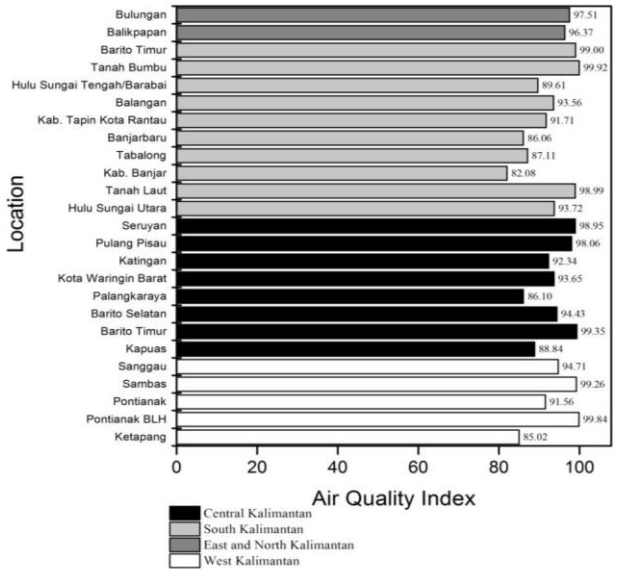

Figure 4 Air Quality Index Each Sampling Location

Air Quality of the Kalimantan Ecoregion

Air quality is one of environmental quality index indicators. In general, AQI in Kalimantan Ecoregion was categorized as good quality in 2016. This result cannot be separated from the existence of forests in this Ecoregion. If we compare AQI in the Kalimantan ecoregion within the last 5 years, the trend tends to fluctuate and increase significantly in 2015, as shown in Figure 5. The increase of trend of AQI was experienced by all provinces within the Kalimantan ecoregion.However, it increased most significantly in the province of East Kalimantan. This result 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 AQIwasrevegetation in some areas of the Kalimantan Ecoregion that has begun to succeed. In addition, initiation of some places industrial forest plantations has been quite successful.

In contrastwiththesituation in East Kalimantan, Figure 5 clearly 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 is still the province with the lowest air quality index.

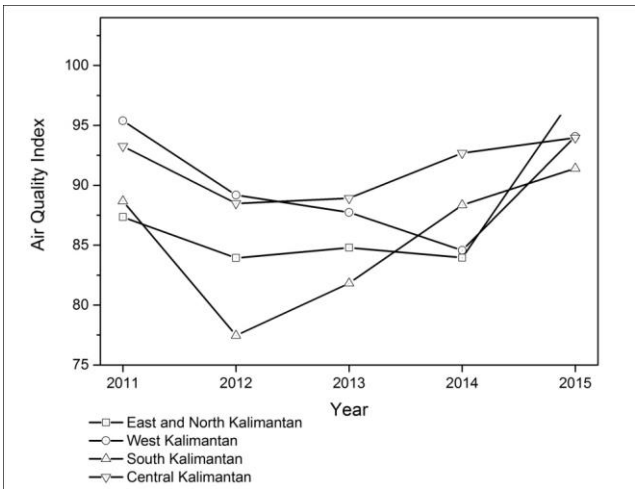

Figure5 Trendof Air Quality Index in Kalimantan Ecoregion (2011-2015)

The Urge of Environmental Education in Kalimantan

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(Gupta, 2010). This country is one of the most vulnerable countries to forest fire, earthquakes, tsunami, floods, volcanoes, droughts, etc. As archipelago country, challenges also appear from transportation issue among the islands. Moreover, huge population of Indonesia makes the challenge for education sector is higher.

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

In the beginning, before education becomes somehow standardized, education is strongly related as the way people understand their environmental situation. Nowadays, this notion is well known for place-based education (Smith, 2007).Recent various researches have shown that student in science influenced by place-based education that affects their community and lives (Semken, 2005, 2008; Riggs, 2005). Therefore, the geographical rationale has positive contribution to the future lives of students. From the result of AQI, the situation in South Kalimantan seems the most vulnerable area. The environmental education in this area needsserious attention fromthe society.

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 important keys when the discussion about the environmentarises. One of the powerful tools to maintain environment is through education (Karatas, 2016).

Sufficient knowledge about natural disaster and disaster management should be taught in Physics and Geography subject 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. Comprehensive discussion about air could be built in science learning. For Kalimantan case, the discussion about SO_2 and the source of it needs to be studied. Because this pollutant gave the most significant impact to the air quality in this island. In 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 research about trend of AQI (Figure 5) can be used as discussion material. Then depending on the level of education, students could give their opinion and possible solution to this issue.

Potential of Environmental Education Related to Air Quality in Kalimantan

Since environmental education related to air quality is urgent, the discussion about the potential topic in Indonesia science curriculum is needed. According to Hungerford et al (1994), the aim of environmental education is maintaining equilibrium between quality of life and environment. Moreover, contextual teaching and learning could develop critical thinking (Tari & Rosana, 2019) and learning outcome (Lotulung, Ibrahim, & Tumurang, 2018). For the students in Kalimantan ecoregion, they will deal with many decisions in their life that relate to this issue. In Kalimantan context, a common example is land clearing in forest area by burning the trees. The students live with this issue as part of their daily life.

Based on the AQI result, we emphasized three major issues about the pollutant, trend of AQI and the low AQI in South Kalimantan. Junior and Senior High School level were chosen with considering the complexity of air quality concept. On the other side, from the curriculum review, six topics are identified as major standards for science education at high school level (Figure 6). The AQI result and the topics in science curriculum are analyzed by the rate of compatibility. From the document analysis, we addressed strongly two main topics related which are substance and its transformation and Science-Environment-Technology-Society meanwhile the others topic could provide secondary support (Table 1). The degree of relation is based on the compatibility of each topic in the curriculum with AQI which range from 1 to 5 (1 for address weekly and 5 for address strongly). The precise development of learning material in these topics is potential advance research in the future.

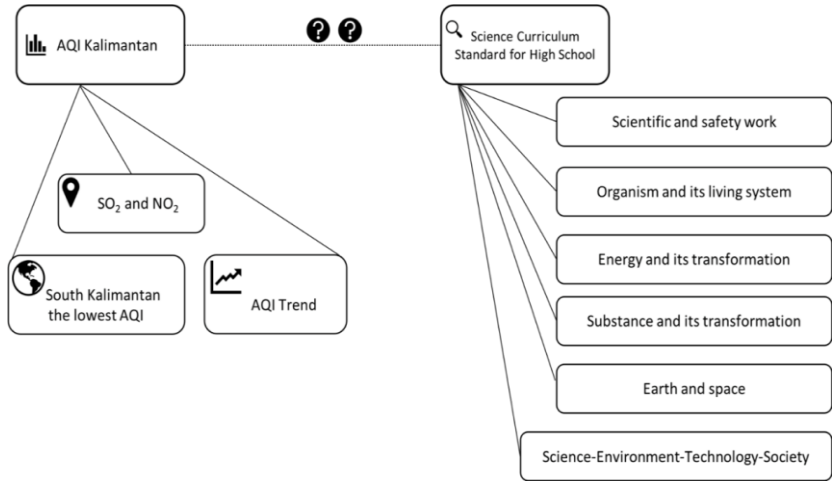

Figure6 Relation Between AQI Result with Science Curriculum

Table 1. Potential Topic in Science Curriculum

No	Topic	Addressed 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 organism Effect of air quality on molecules, cells, tissues, organs, etc.
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 SO2
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 AND LIMITATION

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Conclusion

The resultshowed that the AQI of Kalimantan in 2015 reached 94.27 that was categorized as a good qualityindex. Among the provinces, East and North Kalimantan reached the highest AQI with 97.63 while South Kalimantan hadthe lowest AQI with 91.41. Furthermore, the NO_2 parameter contributed much larger than SO_2 parameters.During 2011-2015, AQI Kalimantan tendedtoincreasealthoughSouth Kalimantan tended to have a lower air quality index than other provinces every year. Thisconditionwasmainlycausedbythetransportationsectorandforestfire. As the impact of this result, as general Kalimantan ecoregion need to maintain the positive trend of AQI and specifically for South Kalimantan that needs serious approaches to deal with low AQI.

From educational point of view, this result shows the urgency of building an understanding from Kalimantan citizen about air quality. From our analysis to science curriculum for Junior and Senior High School level, discussion about air quality could be enhanced in two major section which are Substance and its transformation section and Science-Environment-Technology-Society section.

Limitation

Considering the area of Kalimantan island in Indonesia (around 550 thousand km^2), it is our biggest challenge to collect the air quality data from sufficient area of sampling. From 4 provinces, 25 places were chosen as sample with considering 3 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 wide area of sampling was the limitation of air pollutant that could be measured. From various air pollutant that recognized, we measured only SO_2 and NO_2.

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Air QualityIndex and The Urgency ofEnvironmental Education in Kalimantan

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?		√			
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
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Methods	• Is the methodology chosen suitable to the nature of the topic studied?		√			
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Air Quality Index and The Urgency of Environmental Education in Kalimantan

Abstract

As one of the logical consequences of the transforming 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 SO_2 dan NO_2 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_2 parameter contributed much larger than SO_2 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 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 to the science curriculum.

Keywords: Air quality, Environmental Education, Kalimantan

INTRODUCTION

The concept of air quality is strongly related to the discussion of the air pollution issue. In serious condition, air quality problem was reported to kill more people worldwide than AIDS, malaria, breast cancer or tuberculosis (Rohde & Muller, 2015; WHO, 2014; 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., 2016; Rohde & Muller, 2015) but rarely align the result with the possible support from educational sectors.

The problem of air quality is a transboundary problem especially in an island that shared among several countries, such as Kalimantan. As Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, transboundary massive haze problems frequently occurred on this 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 a lot of 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 is able to 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 an important 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 extremely 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 really needs to be built since childhood, and formal education play 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 crucial challenge within the country and globally (Parker & Prabawa-Sear, 2019). However, environmental education is not considered as priority yet in Indonesia educational system. Until now, the environmental education curriculum still cannot be found explicitly in the body of formal education curriculum (Prihantoro, 2015; Saito et al., 2017). In well-developed countries like the USA or Japan (Fasolya, 2016; Kodama, 2017), environmental education is seriously 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 & Roektiningroem, 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 aimed 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.

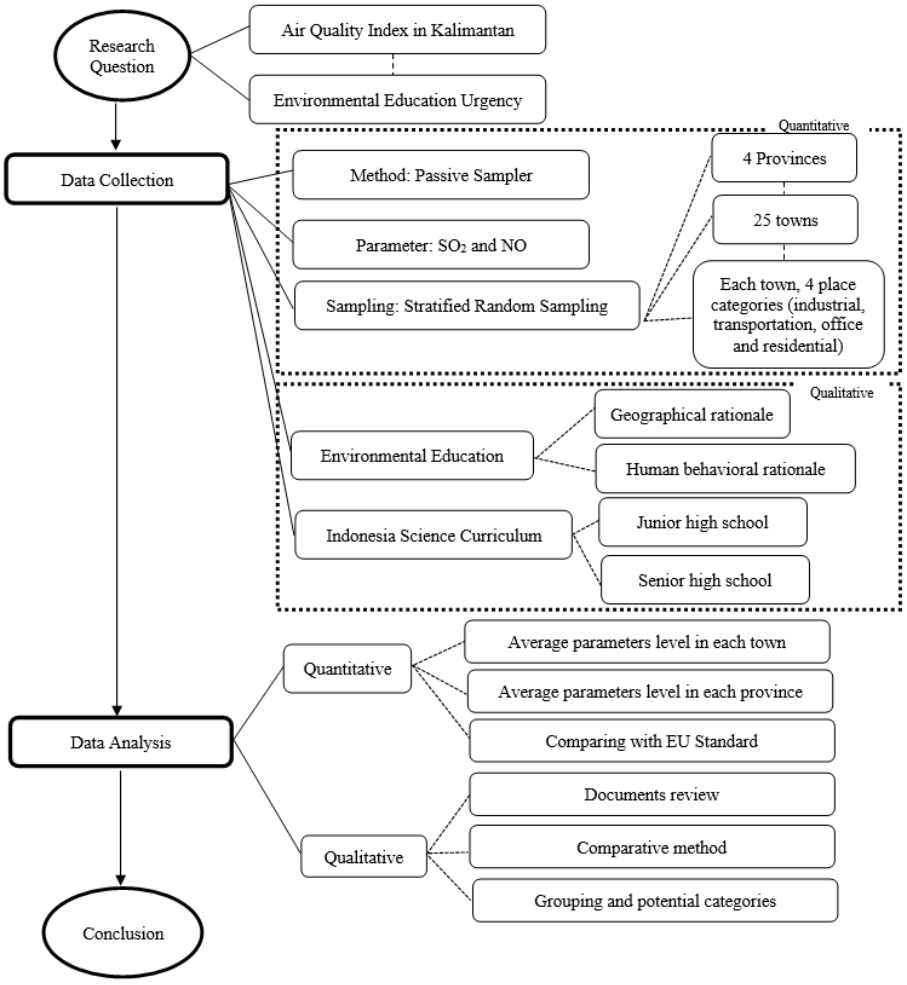

Figure 1. Research methodology

SO_2 and NO_2 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 (Ghanbari Ghozikali et al., 2014; Kim et al., 2013; Masiol et al., 2014). Therefore, these parameters are essensial.

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 important 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 an effective tool in detecting atmospheric metals, such as CO (Khuriganova et al., 2019; McGrath & Scanaill, 2013; Salim & Górecki, 2019). This method is based on the principle of passive diffusion of a pollutant through an air layer to an absorbing medium. This research was conducted in 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 location. All the formulas followed the adaptation from Indonesia government through the Ministry of Environment and Forestry (MNLKH, 2018)

The mean values of SO_2 or NO_2 in a sampling location were calculated by the following equation:

$$a = \frac{a_1 + a_2 + a_n}{n} \quad (1)$$

where *a* is the mean value of SO_2 or NO_2 concentration (µg/Nm^3) in a sampling location. This formula is applied to all other sampling locations (eg *a, b, c,* and *d,* are the mean values of SO_2 or NO_2 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

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

where 20 µg/Nm^3 and 40 µg/Nm^3 are the quality standards (target values) of SO_2 and NO_2, respectively. More than these limits recognized as harmful for human. The I_{eu} value was then converted into the AQI using the following equation:

$$AQI = 100 - \left(\frac{50}{0.9} \times (I_{eu} - 0.1)\right) \quad (3)$$

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 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 km^2), 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 with considering 4 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 recognized, we measured only SO_2 and NO_2. These two parameters recognized as a valid measurement of air pollutants, strongly effect to human health, and have a high possibility to be understood by common citizen especially middle school level students.

For the qualitative data, the AQI result, former research about environmental education such as the general definition and it's urgency (Ardoin et al., 2020; Jorgenson et al., 2019; Parikesit & Withaningsih, 2018) and research in specific topics in environmental education (McGrath & Scanaill, 2013; Saito et al., 2017; Suryawati et al., 2020) and also Indonesia science curriculum for junior and senior high school (Indonesia Ministry of Education and Culture, 2013), were analyzed. Firstly, these documents were selected and labeled to identify meaningful and relevant parts of the documents (Suri, 2020). Then those documents that have been identified through the first process was 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 degree of relationship is based on the compatibility of each topic in the curriculum with AQI which ranges from 1 to 5 (1 for address weekly and 5 for address strongly). Two science education department lectures and two science teachers were involved in group discussion to rate the compatibility.

RESULT 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 the situation of each province were provided. In the context of our study, the AQI was monitored by two parameters. Therefore, the result of NO_2 and SO_2 levels are discussed for each province. Moreover, the details of AQI for all sampling districts were presented. To understand the bigger trend, elaboration of our result with the earlier results were discussed. As a continuation of the quantitative result, the qualitative data were discussed specifically 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

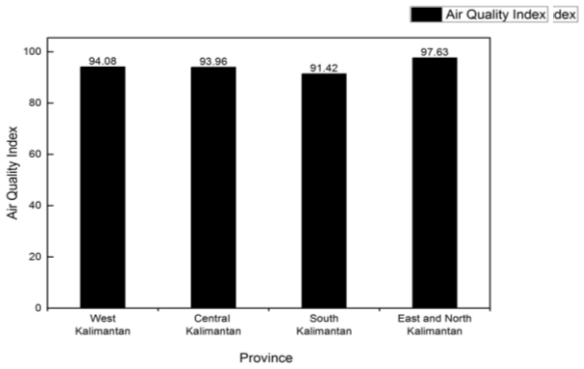

Figure 3. Air quality index each province in Kalimantan

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. 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 eat al., ~~Yan, Liu, & Qu~~, 2015; Xu et al., 2019). 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 South Kalimantan province, with 5.13 µg/Nm^3 of SO_2 and 10.1 µg/Nm^3 of NO_2. The maximum level for SO_2 is 20 µg/Nm^3 and NO_2 is 40 µg/Nm^3 (EEA, 2018; Purnamadewi et al., 2019). More than these limits recognized as harmful for human. 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 province, 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 to the quality of environment (Subagiyo et al., 2019).

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The high value of SO_2 and NO_2 parameters was greatly influenced by the high number of motor vehicles that dispose of burning emissions into the air (Kobza & Geremek, 2017; Krotkov et al., 2016). The use of energy for the transportation sector is dominated using fuel oil. The growth of motorcycle number brings negative 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, 2015). Since South Kalimantan is smaller in area, so the density of vehicles is greater 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 wash 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.

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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; Hiroshi 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 major 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 Banjar district with only 82.08 but still categorized as very good quality.

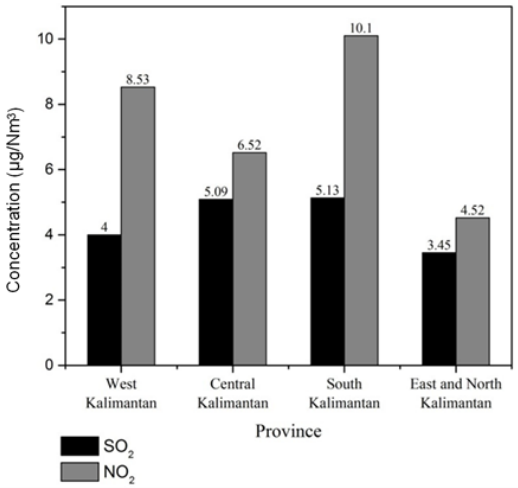

Figure 3 Comparison of SO_2 and NO_2 concentrations per province

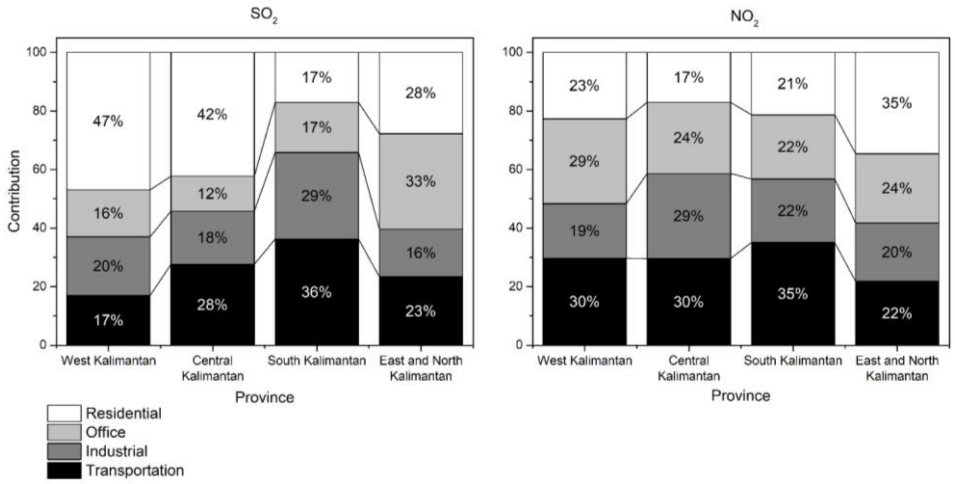

Figure 4 Contribution of location categories to the concentration of SO_2 and NO_2

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 (Badar, 2015; Effendi, 2015; Gultom, 2015; Sukardi, 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 comparison with East Kalimantan, the population in West area is four time bigger in 2015 (Badar, 2015; Effendi, 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 citizen especially in West area.

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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). Based on the observation in this area, poor air quality was almost evenly distributed throughout Banjar Regency because smoke haze enveloped the entire area unhindered by space. Even the poor quality of air could be seen by the naked eye 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. This result cannot be separated from the existence of forests in this Ecoregion. If we compare AQI in the Kalimantan ecoregion within the last 5 years, the trend fluctuated from 2011 to 2014, and increased significantly in 2015, as shown in Figure 6. The increase of the trend of AQI was experienced by all provinces within the Kalimantan ecoregion. However, it increased most significantly in the province of East Kalimantan. This result 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.

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 biggest contributors of air pollutants. These factors emphasize the importance to increase citizen understanding and environmental awareness especially related to air quality. As the important starting point, we argue that 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 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 (The world bank, 2019). This country is one of the most vulnerable countries to forest fire, earthquakes, tsunami, floods, volcanoes, droughts, etc. As an archipelago country, challenges also appear from transportation issues among the islands. Moreover, a huge population of Indonesia makes the challenge for the education sector is higher.

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 become the major 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 also in line with the world-wide 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 important 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 Kalimantan case, the discussion about SO_2 and the source of it needs to be studied. Because this pollutant gave the most significant impact on the air quality in this island. In 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 research 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.

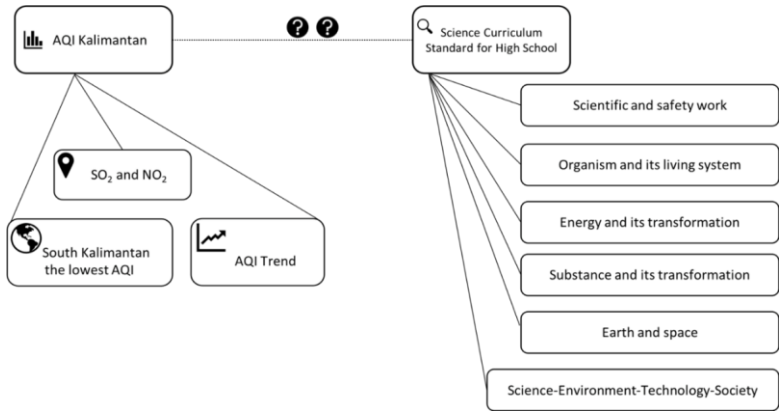

Figure 7. Relation between AQI result with science curriculum

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; Mensah & Casadevall, 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 common 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 major 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 major standards for science education at the high school level (Figure 7). The AQI result and the topics in the science curriculum were analyzed by the rate of compatibility. From the document analysis, we addressed strongly 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 science curriculum

No	Topic	Addressed 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, etc.
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	Composition, structure, and properties of SO_2 and NO

			Physical and chemical changes involving SO_2 and NO	SO_2 and NO reactions with other substances/ compounds The formation of acid rain due to the influence of SO2
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 a 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 NO_2 parameter contributed much larger than SO_2 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 biggest contributors for air pollutant are residential and transportation categories which signifies the education about good management of settlements and transportations is 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 to the science curriculum.

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Air Quality Index and The Urgency of Environmental Education in Kalimantan

Abstract

While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, 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 the urgency of environmental education toward this result becomes essential to explore. Air Quality Index (AQI) measured by a passive sampling method with SO_2 dan NO_2 as parameters of pollutants. 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_2 parameter contributed much larger than SO_2 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 possible enhancement in Substance and its transformation section and the Science-Environment-Technology-Society section in Science for Junior and Senior High School.

Keywords: Air quality, Environmental Education, Kalimantan

Commented [U1]: The authors should introduce briefly the effects of NO_2 and SO_2 on human.

INTRODUCTION

Commented [U2]: - The introduction discusses all aspects of the study.
- The aims of the paper have been achieved

As one of the logical consequences of the transforming process from agricultural to industrial societies, human activities contribute some pressures to our environment especially air quality. The concept of air quality is strongly related to the discussion of the air pollution issue. In serious condition, air quality problem was reported to kill more people worldwide than AIDS, malaria, breast cancer, or tuberculosis (Rohde & Muller, 2015; WHO, 2014; 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; L.Worden, 2011; Masiol et al., 2014; Monteiro et al., 2016; Rohde & Muller, 2015) but rarely align the result with the possible support from educational sectors.

The problem of air quality is a transboundary problem especially in an island that shared among several countries, such as Kalimantan. While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, transboundary massive haze problems frequently occurred on this 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 a lot of 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 is able to 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 an important period to explore more detail.

Exploring the relation of 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 children with polluted air has been proven to bring a serious effect on their health 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 extremely 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.

On the other hand, environmental education is not considered a priority yet in Indonesia educational system. In well-developed countries like the USA or Japan (Fasolya, 2016; Kodama, 2017), environmental education is seriously 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 & Roektiningroem, 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 aimed to measure the air quality index (from 2011 to 2015) through understandable and valid measurements on some locations on Kalimantan and align the 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 2015-2017. SO_2 and NO_2 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 (Ghanbari Ghozikali et al., 2014; Kim et al., 2013; Masiol et al., 2014).

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If yes, the general trends can be performed.

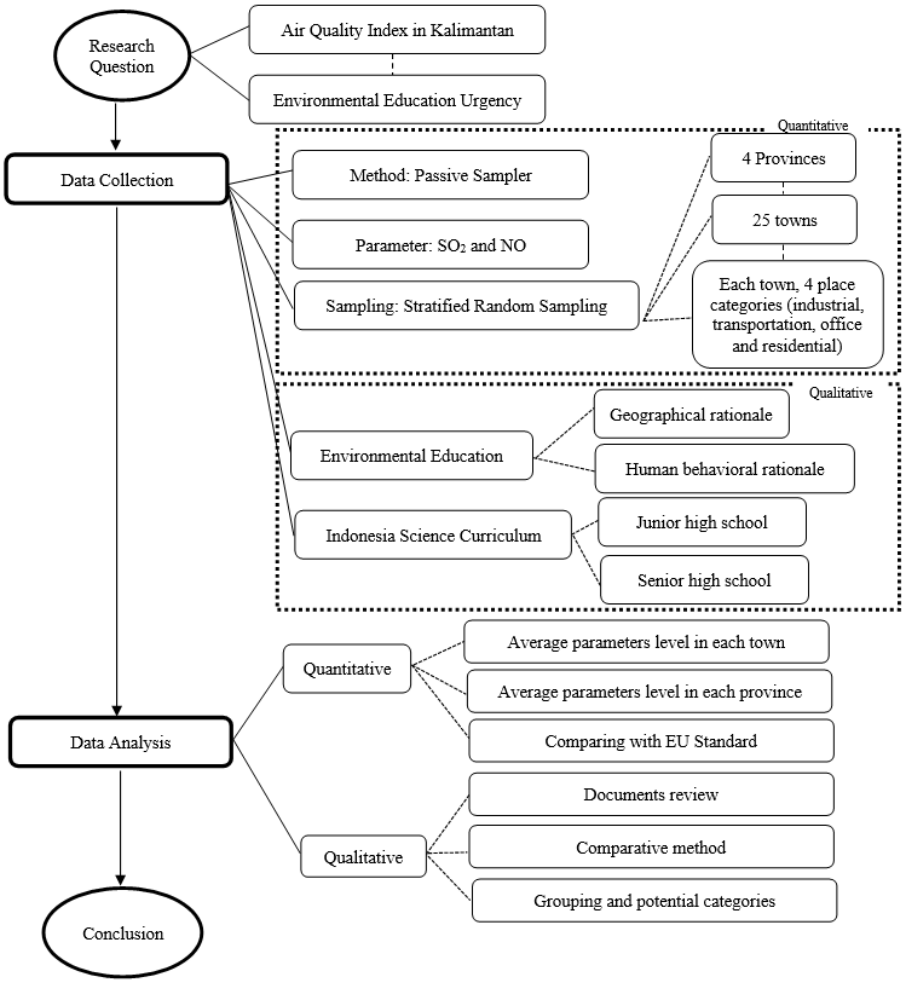

Figure 1. Research Methodology

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 important 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 an effective tool in detecting atmospheric metals, such as CO (Khuriganova et al., 2019; McGrath & Scanaill, 2013; Salim & Górecki, 2019). This method is based on the principle of passive diffusion of a pollutant through an air layer to an absorbing medium. This research was conducted in 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. All the formulas followed the adaptation from Indonesia government through the Ministry of Environment and Forestry (MNLKH, 2018)

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The mean values of SO_2 or NO_2 in a sampling location were calculated by the following equation:

$$a = \frac{a_1 + a_2 + a_n}{n} \quad (1)$$

where *a* is the mean value of SO_2 or NO_2 in a sampling location. This formula is applied to all other sampling locations (eg *a, b, c,* and *d,* are the mean values of SO_2 or NO_2 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

Commented [U5]: What is the unit of SO_2 or NO_2?

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

where 20 and 40 are the quality standards (target values) of SO_2 and NO_2, respectively. The I_{eu} value was then converted into the AQI using the following equation:

$$AQI = 100 - \left(\frac{50}{0.9} \times (I_{eu} - 0.1)\right) \quad (3)$$

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 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 km^2), 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 with considering ~~3~~ 4 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 recognized, we measured only SO_2 and NO_2. These two parameters recognized as a valid measurement of air pollutants, strongly effect to human health, and have a high possibility to be understood by common citizen especially middle school level students.

For the qualitative data, the AQI result, former research about environmental education, and 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 related and needed information that was identified through the first process was justified as the urgency of environmental education in Kalimantan. Moreover, analysis of the science curriculum in Indonesia was held to outline the potential topics that possibly strengthen environmental education in Kalimantan, especially in air quality issues.

RESULT 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 the situation of each province were provided. In the context of our study, the AQI was monitored by two parameters. Therefore, the result of NO_2 and SO_2 levels are discussed for each province. Moreover, the details of AQI for all sampling districts were presented. To understand the bigger trend, elaboration of our result with the earlier results were discussed. As a continuation of the quantitative result, the qualitative data were discussed specifically 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. 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). Therefore, our result in Kalimantan was consistent throughout the season fluctuation.

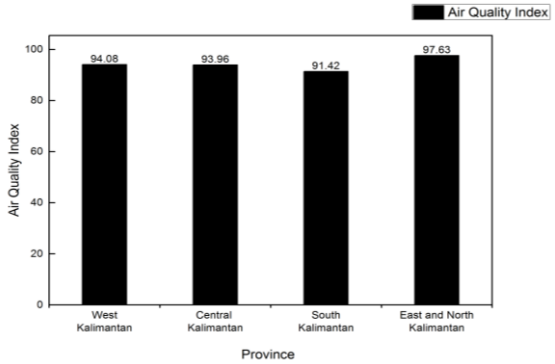

Figure 2. Air Quality Index Each Province in Kalimantan 2016

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 South Kalimantan province, SO_2 with 5.13 µg/m^3 and NO_2 with 10.1

Commented [U6]: Year 2015 or 2016?

It means that in this year the air quality was good? How the relationship between the AQI values and the contribution of forest fire and transportation?

The data from each category was not presented?

µg/m^3. The high value of SO_2 and NO_2 parameters was greatly influenced by the high number of motor vehicles that dispose of burning emissions into the air (Kobza & Geremek, 2017; Krotkov et al., 2016). Transportation sectors gave the most influence on the emission. The use of energy for the transportation sector is dominated using fuel oil. The growth of motorcycle number brings negative 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, 2015). Since South Kalimantan is smaller in area, so the density of vehicles is greater 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. 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.

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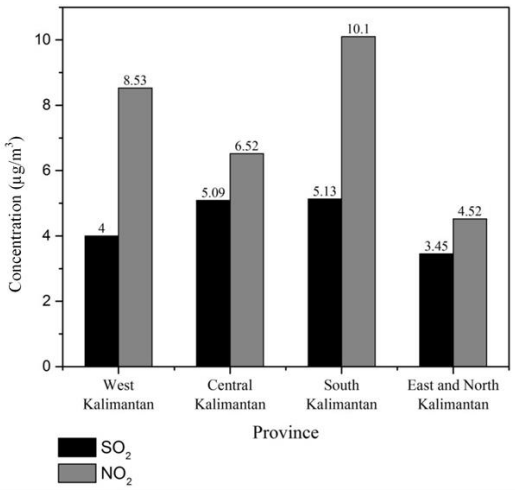

Figure 3 Comparison ~~graphs of~~ SO_2 and NO_2 concentrations per ~~Province~~province.

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; Hiroshi 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 major 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 4. 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 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 (Badar, 2015; Effendi, 2015; Gultom, 2015; Sukardi, 2015). Consequently, the efforts to meet people's needs lead to the exploitation of natural resources such as forests, minerals, and natural gas oil. 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 people.

From the data in Figure 4, 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 district. Poor air quality was almost evenly distributed throughout Banjar Regency because smoke haze enveloped the entire area unhindered by space. Even the poor quality of air could be seen by the naked eye because almost every day shrouded in haze, especially early morning until late afternoon.

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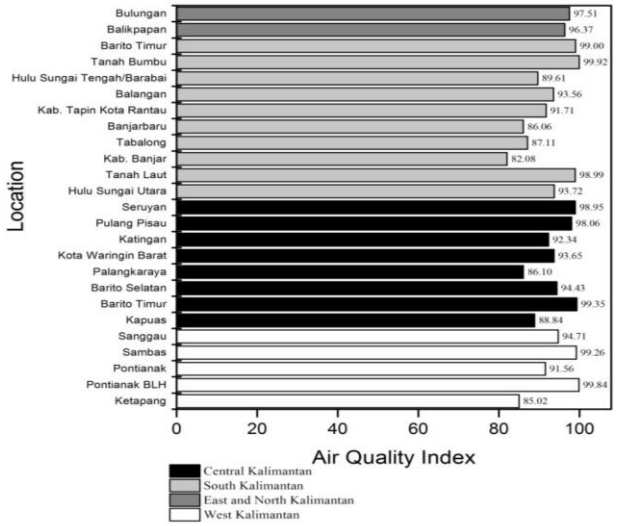

Figure 4 Air Quality Index Each Sampling Location

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. This result cannot be separated from the existence of forests in this Ecoregion. If we compare AQI in the Kalimantan ecoregion within the last 5 years, the trend fluctuated from 2011 to 2014, and increased significantly in 2015, as shown in Figure 5. The increase of the trend of AQI was experienced by all provinces within the Kalimantan ecoregion. However, it increased most significantly in the province of East Kalimantan. This result 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.

In contrast with the situation in East Kalimantan, Figure 5 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.

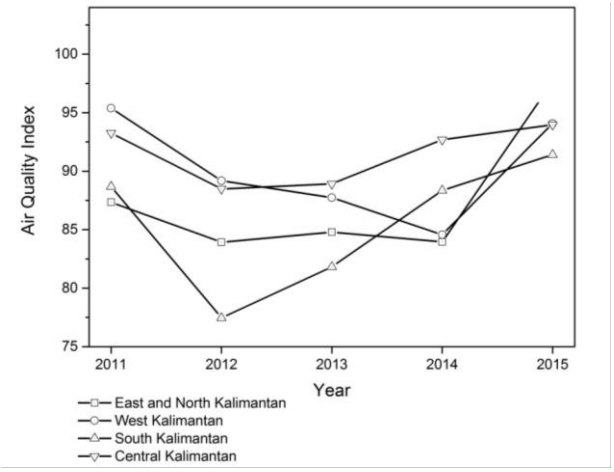

Figure 5. Trend of Air Quality Index in Kalimantan Ecoregion (2011-2015)

The Urgency of Environmental Education in Kalimantan

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 (The world bank, 2019). This country is one of the most vulnerable countries to forest fire, earthquakes, tsunami, floods, volcanoes, droughts, etc. As an archipelago country, challenges also appear from transportation issues among the islands. Moreover, a huge population of Indonesia makes the challenge for the education sector is higher.

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 become the major 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 also in line with the world-wide 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 important keys when the discussion about

the environment arises. One of the powerful tools to maintain the environment is through education (Karataş A & 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 Kalimantan case, the discussion about SO_2 and the source of it needs to be studied. Because this pollutant gave the most significant impact on the air quality in this island. In 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 research about trend of AQI (Figure 5) 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; Mensah & Ricart Casadevall, 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 common 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 major 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 major standards for science education at the high school level (Figure 6). The AQI result and the topics in the science curriculum were analyzed by the rate of compatibility. From the document analysis, we addressed strongly 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 degree of relationship is based on the compatibility of each topic in the curriculum with AQI which ranges from 1 to 5 (1 for address weekly and 5 for address strongly). The precise development of learning material in these topics becomes potential research in the future.

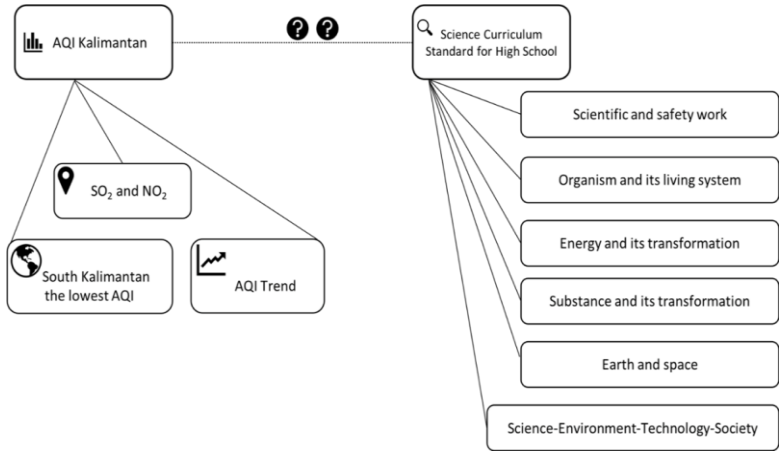

Figure 6. Relation Between AQI Result with Science Curriculum

Table 2. Potential Topic in Science Curriculum

No	Topic	Addressed 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, etc.
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 SO2
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 a 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 NO_2 parameter contributed much larger than SO_2 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 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 educational point of view, 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.

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Paper title:

Air Quality Index and The Urgency of Environmental Education in Kalimantan

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?		√			
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?		√			
	• Is research question of the study clear and understandable?		√			
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?		√			
Methods	• Is the methodology chosen suitable to the nature of the topic studied?		√			
	• Is the methodology of the research described clearly?(including study design, location, subjects, data collection, data analysis)		√			
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
	• Are the validity and reliability of data collection tools established? (only for empirical studies)	√				
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)	√				
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?	√				
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the "discussion" section of the manuscript adequately relate to the current and relevant litarature?		√			
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
Conclusion	• Is the conclusion clear and in the form of a narration instead of pointers?		√			
	• Isn't the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√			
	• Are the writing of references correct?		√			
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?		√			
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
	• Are there strong consistencies among the parts of the manuscript? (introduction,		√			

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Air Quality Index and The Urgency of Environmental Education in Kalimantan

Abstract

While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, 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 the urgency of environmental education toward this result becomes essential to explore. Air Quality Index (AQI) measured by a passive sampling method with SO_2 dan NO_2 as parameters of pollutants. These two parameters recognized as a valid measurement of air pollutants, strongly effect to human health, and understandable by common citizen 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_2 parameter contributed much larger than SO_2 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 possible enhancement in Substance and its transformation section and the Science-Environment-Technology-Society section in Science for Junior and Senior High School.

Keywords: Air quality, Environmental Education, Kalimantan

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INTRODUCTION

As one of the logical consequences of the transforming process from agricultural to industrial societies, human activities contribute some pressures to our environment especially air quality. The concept of air quality is strongly related to the discussion of the air pollution issue. In serious condition, air quality problem was reported to kill more people worldwide than AIDS, malaria, breast cancer, or tuberculosis (Rohde & Muller, 2015; WHO, 2014; 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; L.Worden, 2011; Masiol et al., 2014; Monteiro et al., 2016; Rohde & Muller, 2015) but rarely align the result with the possible support from educational sectors.

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The problem of air quality is a transboundary problem especially in an island that shared among several countries, such as Kalimantan. While Kalimantan Island as the third largest island on Earth expected to be the lungs of the world, transboundary massive haze problems frequently occurred on this 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 a lot of 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 is able to 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 an important period to explore more detail.

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Exploring the relation of 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 children with polluted air has been proven to bring a serious effect on their health 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 extremely 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.

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On the other hand, environmental education is not considered a priority yet in Indonesia educational system. In well-developed countries like the USA or Japan (Fasolya, 2016; Kodama, 2017), environmental education is seriously 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 & Roektiningroem, 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 aimed to measure the air quality index (from 2011 to 2015) through understandable and valid measurements on some locations on Kalimantan and align the result with possible integration in Indonesia's science curriculum.

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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. ~~-2017.~~ SO_2 and NO_2 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 (Ghanbari Ghozikali et al., 2014; Kim et al., 2013; Masiol et al., 2014).

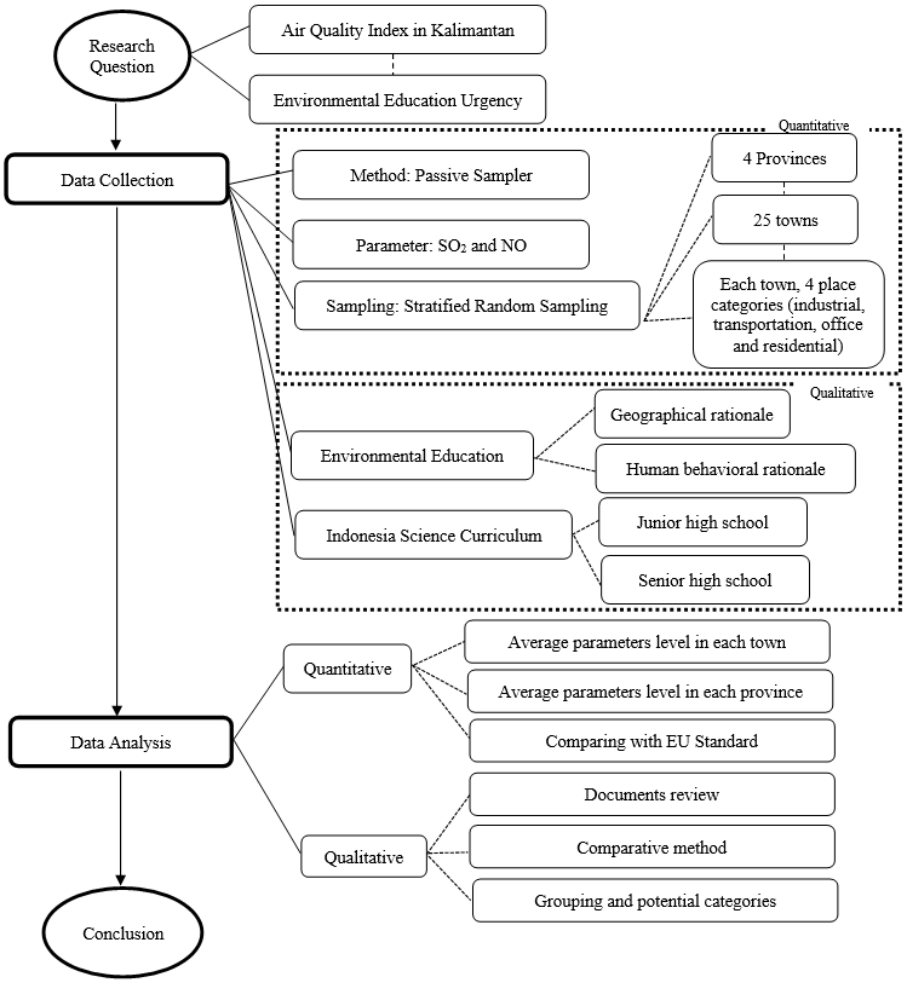

Figure 1. Research methodology

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 important 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 an effective tool in detecting atmospheric metals, such as CO (Khuriganova et al., 2019; McGrath & Scanaill, 2013; Salim & Górecki, 2019). This method is based on the principle of passive diffusion of a pollutant through an air layer to an absorbing medium. This research was conducted in 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 location. All the formulas followed the adaptation from Indonesia government through the Ministry of Environment and Forestry (MNLKH, 2018)

The mean values of SO_2 or NO_2 in a sampling location were calculated by the following equation:

$$a = \frac{a_1 + a_2 + a_n}{n} \quad (1)$$

where *a* is the mean value of SO_2 or NO_2 concentration (µg/Nm^3) in a sampling location. This formula is applied to all other sampling locations (eg *a, b, c,* and *d,* are the mean values of SO_2 or NO_2 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

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

where 20 µg/Nm^3 and 40 µg/Nm^3 are the quality standards (target values) of SO_2 and NO_2, respectively. More than these limits recognized as harmful for human. The I_{eu} value was then converted into the AQI using the following equation:

$$AQI = 100 - \left(\frac{50}{0.9} \times (I_{eu} - 0.1)\right) \quad (3)$$

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 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 km^2), 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 with considering ~~3~~ 4 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 recognized, we measured only SO_2 and NO_2. These two parameters recognized as a valid measurement of air pollutants, strongly effect to human health, and have a high possibility to be understood by common citizen especially middle school level students.

For the qualitative data, the AQI result, former research about environmental education, and 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 related and needed information that was identified through the first process was justified as the urgency of environmental education in Kalimantan. Moreover, analysis of the science curriculum in Indonesia was held to outline the potential topics that possibly strengthen environmental education in Kalimantan, especially in air quality issues.

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RESULT 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 the situation of each province were provided. In the context of our study, the AQI was monitored by two parameters. Therefore, the result of NO_2 and SO_2 levels are discussed for each province. Moreover, the details of AQI for all sampling districts were presented. To understand the bigger trend, elaboration of our result with the earlier results were discussed. As a continuation of the quantitative result, the qualitative data were discussed specifically 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. 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). Therefore, our result in Kalimantan was consistent throughout the season fluctuation.

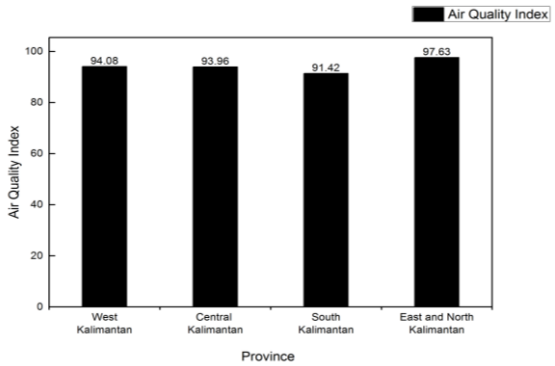

Figure 2. Air quality index each province in Kalimantan

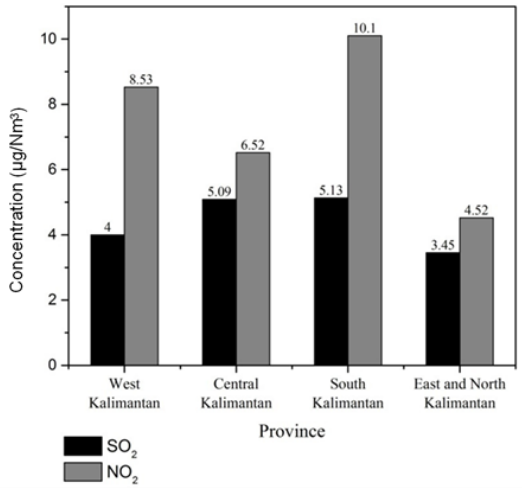

Figure 3 Comparison ~~graphs of~~ SO_2 and NO_2 concentrations per ~~Province~~province.

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 South Kalimantan province, with 5.13 µg/Nm^3 of SO_2 and 10.1 µg/Nm^3 of NO_2. The maximum level for SO_2 is 20 µg/Nm^3 and NO_2 is 40 µg/Nm^3 (EEA, 2018; Purnamadewi et al., 2019). More than these limits recognized as harmful for human. 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 province, except East and North Kalimantan. In general, transportation sectors gave the most influence on the emission, especially South Kalimantan. The high value of SO_2 and NO_2 parameters was greatly influenced by the high number of motor vehicles that dispose of burning emissions into the air (Kobza & Geremek, 2017; Krotkov et al., 2016). The use of energy for the transportation sector is dominated using fuel oil. The growth of motorcycle number brings negative effects to environmental

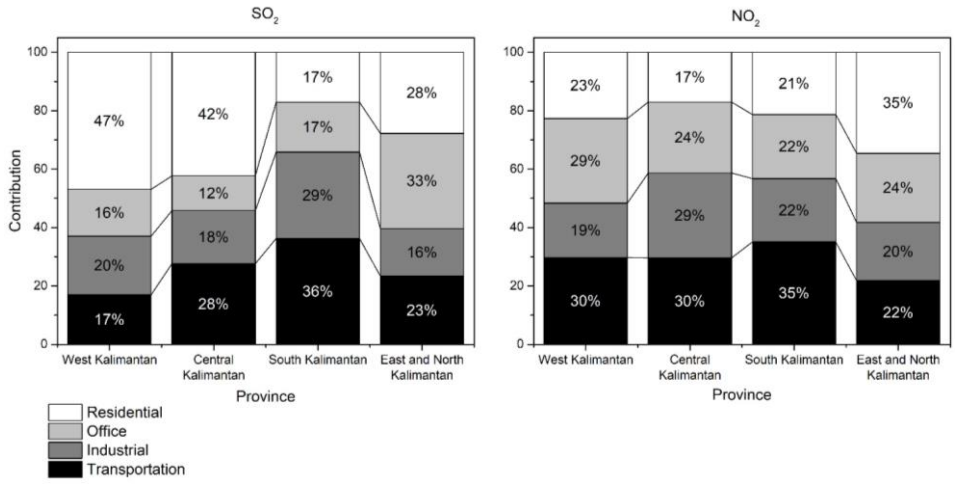

Figure 4 Contribution of location categories to the concentration of SO_2 and NO_2

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, 2015). Since South Kalimantan is smaller in area, so the density of vehicles is greater 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 wash 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; Hiroshi 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 major 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 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 (Badar, 2015; Effendi, 2015; Gultom, 2015;

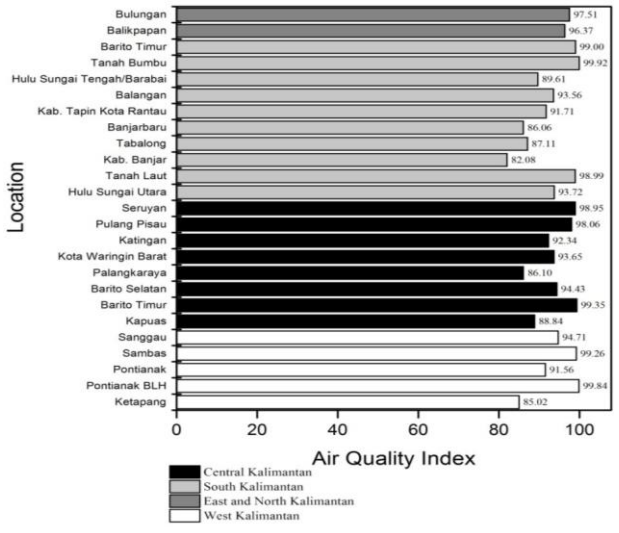

Figure 5 Air quality index each sampling location

Sukardi, 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 comparison with East Kalimantan, the population in West area is four time bigger in 2015 (Badar, 2015; Effendi, 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 citizen especially in West area.

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). Based on the observation in this area, poor air quality was almost evenly distributed throughout Banjar Regency because smoke haze enveloped the entire area unhindered by space. Even the poor quality of air could be seen by the naked eye 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. This result cannot be separated from the existence of forests in this Ecoregion. If we compare AQI in the Kalimantan ecoregion within the last 5 years, the trend fluctuated from 2011 to 2014, and increased significantly in 2015, as shown in Figure 6. The increase of the trend of AQI was experienced by all provinces within the Kalimantan ecoregion. However, it increased most significantly in the province of East Kalimantan. This result 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.

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.

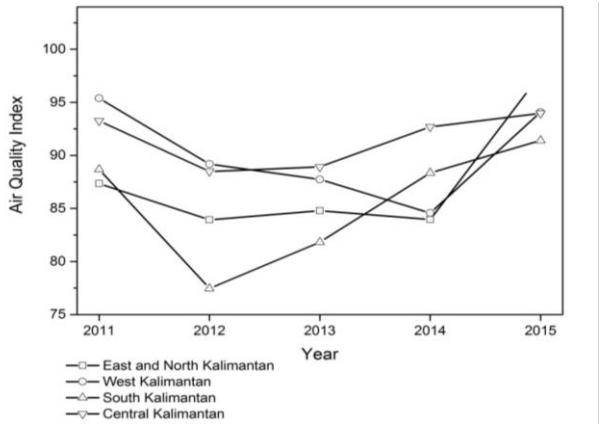

Figure 6. Trend of air quality index in Kalimantan ecoregion (2011-2015)

The Urgency of Environmental Education in Kalimantan

From our result in Figure 4, residential and transportation categories became the biggest contributors of air pollutants. These factors emphasize the importance to increase citizen understanding and environmental awareness especially related to air quality. As the important starting point, we argue that 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 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 (The world bank, 2019). This country is one of the most vulnerable countries to forest fire, earthquakes, tsunami, floods, volcanoes, droughts, etc. As an archipelago country, challenges also appear from transportation issues among the islands. Moreover, a huge population of Indonesia makes the challenge for the education sector is higher.

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 become the major 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 also in line with the world-wide 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 important keys when the discussion about the environment arises. One of the powerful tools to maintain the environment is through education (Karataş A & 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 Kalimantan case, the discussion about SO_2 and the source of it needs to be studied. Because this pollutant gave the most significant impact on the air quality in this island. In 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 research 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; Mensah & Ricart Casadevall, 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 common example is the land clearing in forest areas by burning the trees. The students live with this issue as part of their daily life.

Commented [U9]: The aspects which was investigated qualitatively, there is no explanation in the results and discussion as asked in the methodology chapter so that the relationship between quantitative and qualitative data is not yet clear. The discussion becomes less detailed because there has been no discussion of every aspect related to the discussion of the environmental education curriculum in schools.

Based on the AQI result, we emphasized three major 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 major standards for science education at the high school level (Figure 7). The AQI result and the topics in the science curriculum were analyzed by the rate of compatibility. From the document analysis, we addressed strongly 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 degree of relationship is based on the compatibility of each topic in the curriculum with AQI which ranges from 1 to 5 (1 for address weekly and 5 for address strongly). The precise development of learning material in these topics becomes potential research in the future.

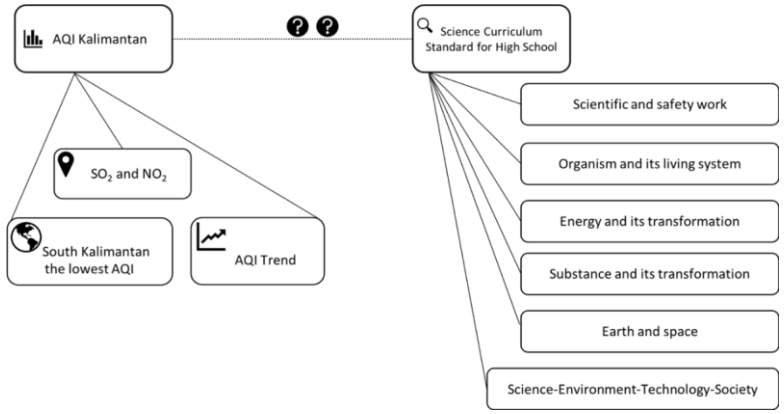

Figure 7. Relation between AQI result with science curriculum

Table 2. Potential topic in science curriculum

No	Topic	Addressed 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, etc.
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 SO2
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 a 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 NO_2 parameter contributed much larger than SO_2 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 educational point of view, 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.

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Paper title:

Air Quality Index and The Urgency of Environmental Education in Kalimantan

Parts of review	Guidelines	Yes	Partly	No	Reviewer's note for improvement	Author's responds (highlight of revision)
Title	• Does the subject matter fit within the scope of journal?	√				
	• Does the title clearly and sufficiently reflect its contents?		√			
Abstract	• Does the abstract contain informative, including Background, Methods, Results and Conclusion?		√			
Back-ground	• Is the background informative and sufficient (include the background problem and objectives)?		√			
	• Is research question of the study clear and understandable?		√			
	• Does the rationale of the study clearly explained using relevant literature?		√			
	• Is the "aim" of the manuscript clear and understandable?		√			
Methods	• Is the methodology chosen suitable to the nature of the topic studied?		√			
	• Is the methodology of the research described clearly?(including study design,		√			

	location, subjects, data collection, data analysis)					
	• Is there adequate information about the data collection tools used? (only for empirical studies)		√			
	• Are the validity and reliability of data collection tools established? (only for empirical studies)	√				
	• Are the data collection tools suitable for the methodology of the study? (only for empirical studies)	√				
Results & Discussion	• Are the tables, graphs and pictures understandable, well presented and numbered consecutively?	√				
	• Do the data analysis and the interpretation appropriate to the problem and answer the objectives?		√			
	• Does the “discussion” section of the manuscript adequately relate to the current and relevant litarature?		√			
	• Are the findings discussed adequately considering the research question(s), sub-question(s) or hypothesis?		√			
Conclusion	• Is the conclusion clear and in the form of a narration instead of pointers?		√			
	• Isn’t the conclusion a summary and consistent between problems, objectives and conclusion?		√			
References	• Do the references and citations match?		√			
	• Are the writing of references correct?		√			
Quality Criteria	• Do the title, problem, objectives, methods and conclusion are in line? Is it well organized?		√			
	• The quality of the language is satisfactory		√			
	• The work relevant and novel		√			
	• Are there strong consistencies among the parts of the manuscript? (introduction, methods, results and discussion, and conclusion)		√			