The Effect Of Physical Characteristics Of Coastal City On The Air Quality

Sungkono[1], Sukoso[2], Abdul Makhsud[3], Rudy Sulistyono[4], Juhana[5]

[1]Doctoral Program of Environmental Science, Postgraduate School, Universitas Brawijaya, sungkono@umi.ac.id
[2]Department of Fisheries Product Technology, Faculty of Fishery and Marine Sciences, Universitas Brawijaya, mrsukoso@yahoo.com
[3]Department of Mechanical Engineering, Faculty of Engineering, Indonesia Muslim University, makhsud@umi.ac.id
[4]Department of Agronomy, Faculty of Agriculture, Universitas Brawijaya, r.sulistyono@yahoo.com
[5]Department of Architecture Engineering, Faculty of Engineering, Indonesia Muslim University, juhana.umi@gmail.com

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Abstract- Coastal city is an area that is still strongly influenced by sea breeze. Characteristics of the sea breeze is blowing during the day from the sea to the land every day, it can be utilized to improve the air quality in urban areas. This study aims to assess the physical characteristics of the coastal city to assess the quality of air. This research was conducted in Makassar, in three locations of city regions which were selected as the observation units to be studied, each area have a radius of 100 m. To support this research, the measurements of wind speed and direction had been conducted in those three regions. Measurements of microclimate conditions at all measuring points were simultaneously carried out five times, since morning to evening in the fair-weather. The aspects of physical characteristics of the environment studied; including building mass, environmental density, building materials, land cover material, and landscapes. The analysis was carried out quantitatively using a formula by Edward Ng (2006) as the indicator and statistical analysis. Air quality was mapped using the ENV-Met V.3.1 software. The result of the analysis shows that the physical characteristics of coastal city had a significant effect on the utilization of local wind to improve air quality.

Index Terms- physical characteristics, coastal city, air quality

I. INTRODUCTION

The coastal area which is characterized by land and water is one of the climate controls that may affect the climate elements in that region. Large water capacity in the ocean prevents heating as fast as it does on the land. During the day, the air above the land is warmer than the air above the ocean. Different pressure causes the sea breeze blowing. At night, the air temperature changes the direction. There is no wind in the time of dusk and dawn, because at those time the land and sea are in the same temperature. Furthermore, at night the wind speed is weaker than during the day since the difference of air temperature between land and sea is smaller [1].

The result of Juhana's research show that sea breeze in Makassar city was still able to reach the land at a distance of 10-20 km from the sea, if there was no any significant obstacles along the surface that was passed [2]. The strategy of utilizing the potential of local wind is an anticipatory step to improve the microclimate, especially to create a comfortable and pleasant environment.

The smooth flow of wind in urban environment highly depends on the conditions of the building characteristics and the existance of vegetation. The result suggests that the form of building mass arrangement, the ratio of height and the slenderness of the building is highly instrumental in determining the smooth flow of wind in the built environment [2].

Hong Kong is the first coastal city in the world that utilized the local wind potential of coastal areas by involving several experts, then formulating the Hong Kong Planning Standards and Guidelines (HKPSG). This standard introduces air flow issues in urban environments associated with the increased air ventilation. This HKPSG was made because of the case of Severe Acute Respiratory Syndrome (SARS) in 2003, which claimed many victims in Hong Kong. The SARS allegedly occurred since the air pollution was confined and piled up in the middle of the city, due to poor air ventilation in Hong Kong [3].

Makassar city is located in South Sulawesi Indonesia. Makassar is one of the big cities in Indonesia located in South Sulawesi which has similar problems as Hong Kong. Makassar is inhabited by more than 1.7 million people. There are many tall buildings that may prevent good air circulation. This study aims to analyze the physical characteristics and the air quality of the coastal city located in Makassar.

II. RELATED WORKS

The level of wind speed that blows into the city could affect the air quality in the region. In the case that occurred in Hong Kong, the use of macro-coastal winds could be calculated by calculating how much instrumental buildings and plants could direct the wind into the city. Ng's research, Edward et al (2006) in several areas of Hong Kong City, used the wind speed ratio (VRw) as an indicator, using the following formula:

$$VR_w = \frac{v_p}{v_\infty}$$

Descriptions :

v_∞ = the wind speed at the boundary layer which is not affected by surface roughness

v_p = the wind speed at road level (2m height) as an impact of surface roughness

VRw = the wind speed ratio indicated by the impact of the existance of a building or plant in a location.

The high VRw value gives an indication of the low impact of buildings or plants on the wind speed.

III. RESEARCH METHOD

The air quality mentioned above means the ambient air quality. As in the air there are pollutant elements (pollutants, both This study used a quantitative method using the formula from Edward Ng to reveal the benefits of wind in urban areas [3]. Empirical data was collected through field observations by using direct recording and direct measurement techniques. The data of wind speed in urban areas was obtained through direct measurements which was conducted in those three observation locations.

Data of the physical characteristics of urban areas related to the building mass, environmental density, building materials, land cover material, and landscapes were collected using tools such as; GPS, angle-finder, meter gauge and camera. Data retrieval of physical characteristics of urban areas in those three research locations was conducted within a radius of 100 m. This study used the basic maps such as topography, earth appearance, aerial photographs from google map, ETM-7 of lansat imagery. Field observations were conducted by using recording techniques, in the form of shooting, recording, observing, and measuring.

The urban areas that were used as a case study in this research were urban areas around G. Bawakaraeng Street (St.) that was ± 1 km from the coastline, A.P. Pettrani St. that was ± 4 km from the coastline (in the downtown area), and Perintis Kemerdekaan St. that was ± 20 km from the coastline. Those areas were determined by the consideration of: 1) being in diverse of landscapes (near the coast, in the downtown, far from the coast), 2) belonging to the sea breeze range zone (maximum 50 km from the coast), 3) the dense urban environments.

The measurement time was determined based on the circulation of the sun and the rush hours; that were at 8:00 a.m., 10:00 a.m., 12:00 p.m., 2:00 p.m., and 4 p.m. The measurements were simultaneously conducted for all measuring points in the fair-weather.

To support the mapping of micro wind characteristics conditions, data collection of physical characteristics in the three urban areas were observed through field observations, aerial photography assistance from Google map of Makassar 2016, topographic maps, earth appearance, and the ETM-7 of lansat imagery. Field observations were conducted by using recording techniques, in the form of shooting, recording, observing, and measuring. The level of local wind speed that blew into the city area could be identified by calculating the magnitude of the effect of buildings and plants that could turn the wind by using the wind speed ratio formula from Edward Ng as an indicator.

The assessment of air quality was based on air pollution content. Ambient air quality was determined good when the concentration of pollutants was still below the standard value. The content of air pollution which was being the subject of study was Carbon Monoxide (CO).

primary and secondary which come from natural activities and most of human activities) which can affect normal air balance and cause disruption to human life, animals and plants, also the other objects, so that the ambient air quality drops to a certain level which causes the ambient air not fulfilling its function. It is considered as good ambient air quality if the concentration of pollutants is still below the standard value.

IV. RESULT AND DISCUSSION

A. Physical Characteristics of City Areas of Makassar

The physical characteristics of the three city areas observed were explained in 2 stages, namely 1) the condition of the physical characteristics of the city area, and 2) the parameter of physical characteristics of the city area. The description of physical characteristics in the three urban areas observed is explained as follows:

Physical Characteristics of Area adjacent to G. Bawakaraeng St.

Figure 1 showed the environmental conditions around G. Bawakaraeng St., in which there were offices complex, shoppings complex (shophouses), settlements, school buildings, sports fields (Karebosi); in the form of small buildings with only 1 floor to 2 floors, trade buildings lined up along the main road consisting of 1 to 3 floors . There were also high-rise buildings with 23 floors.

A.Aerial photography around the area of the observation location St. G. Bawakaraeng of Makassar city by google earth, 2017

Legend:
1. St. G. Bawakaraeng
2. Primary School Building
3. Office complex
4. Shopping complex (shophouses)
5. Kindergarten building
6. Office building, Bosowa tower

B.Aerial photography around the area of the observation location St. G. Bawakaraeng of Makassar city by google earth, 2016

Figure 1: Physical characteristics of areas adjacent to G. Bawakaraeng St.

The mass of each building in this region was diverse, some of the buldings were elongated (flat), wide (thick), and small in size. Land cover was dominated by hardening of asphalt and paving blocks, there were only a small part of it which was covered with grass. Trees were mostly on the west and south sides of the building mass.

Physical Characteristics of Area adjacent to A.P. Pettarani St.

Figure 2 showed the environmental conditions around St. A.P. Pettarani, in which there were offices complex, shops complex (shophouses), settlements; in the form of small buildings with only 1 floor to 2 floors, trade buildings lined up following the main road line consisting of 1 to 3 floors. In the location there are also high-rise buildings with 18 floors (Graha Pena building).

A.Aerial photography around the area of the observation location St. A.P. Pettarani of Makassar city by google earth, 2017

Legend:
1. St. A.P. Pettarani
2. Overpass
3. Office building
4. Shopping complex (shophouses)
5. Shopping complex
6. Settlements
7. Police station

B.Aerial photography around the area of the observation location St. A.P. Pettarani of Makassar city by google earth, 2016

Figure 2:Physical characteristics of area adjacent to A.P. Pettarani St.

The mass of each building in this region was diverse, some were elongated (flat), wide (thick), and small in size. Land cover was dominated by hardening of concrete and paving blocks, only a small parts of it which was covered by grass. This area had eight main road lanes with concrete material. This area was crossed by 2-lanes of overpass. Trees were mostly on the west and south sides of the building mass.

Physical Characteristics of Area adjacent to Perintis Kemerdekaan St.

Figure 3 showed the environmental conditions around St. Perintis Kemerdekaan, in which there were offices complex, shops complex (shop houses), settlements; in the form of small buildings with floors 1 to 2, the buildings of trading area which consisted of 1 to 3 floors were lined up following the main road line. In this location, there were also four-lane roads that cut-off to the sea and were also a cut-off road from the industrial area.

A.Aerial photography around the area of the observation location St. Perintis Kemerdekaan of Makassar city by google earth, 2017

Legend:
1. St. Perintis Kemerdekaan
2. Cut-off road to industrial park
3. Office building
4. Shopping complex (shophouses)
5. Shopping complex
6. Settlements
7. Park

B.Aerial photography around the area of the observation location St. Perintis Kemerdekaan of Makassar city by google earth, 2016

Figure 3: Physical characteristics of area adjacent to Perintis Kemerdekaan St.

The mass of each building in this region was diverse, some were elongated (flat) and the majority of them were small. Land cover was dominated by hardening of concrete and paving blocks, a small part of it was covered by grass. Trees were mostly on the west, north and east sides of the building mass.

B. Parameters of the Physical Environmental Characteristics

The main parameters of physical characteristics of the city area were; building mass (aspect ratio, slenderness ratio, roof and wall cover, building orientation), environmental density (building coverage ratio (BCR), floor area ratio (FAR) and building volume), building material (heavy material, light material, albedo material value), land cover material (hard material, soft material, albedo value material of land, tree), as well as landscape (elevation, contour, and distance from the coast) The parameters of physical characteristics in the three urban areas observed were described as follows:

The Mass of Building

The building mass is explained through aspect ratio (AR), slenderness ratio (SA), roof cover (RC) and wall (RW), and building orientation (RO).

The comparison of the mass of buildings in the three urban areas (Figure 4) showed that the area of Perintis Kemerdekaan St. had the most flat building (3.04), followed by that in the Pettarani St. (2.92) and the widest building construction was in the area of G. Bawakaraeng St. (2.45). The environment that had the highest slenderness of buildings was the G. Bawakaraeng St. (0.92), followed by PP. Pettarani St. (0.78) and the shortest building construction was in Perintis Kemerdekaan St. (0.64). The area of G. Bawakaraeng St. had the highest ratio of roof area / building volume (2.40) and wall / building volume (2.50), but it was the smallest East-West oriented building (0.30). It was different from Perintis Kemerdekaan St. which had the smallest ratio of roof area / building volume (0.90) and wall / building volume (1.10), yet the building tended to be East-West oriented (1.20). The area of PP. Pettarani St. had a ratio of roof area / building volume (2.31) and wall / building volume (2.48) and it was the highest East-West oriented building (2.01).

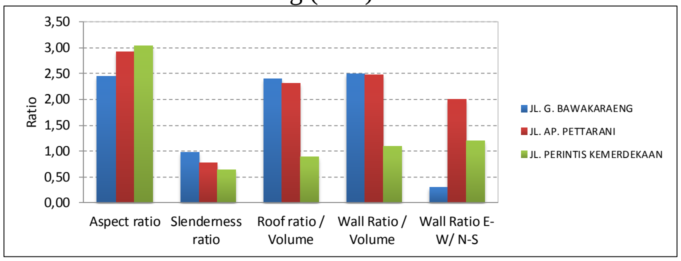

Figure 4: Characteristics of buildings mass in three urban areas

The Density of Urban Area

The density of urban area is explained through the basic building coverage ratio (BCR), floor area ratio (FAR), and building volume in the environment (VBE).

Comparison of densities in those three urban areas (Figure 5), showed that the area of G. Bawakaraeng St. was *the densest* urban *environment* compared to other regions, with the BCR average was around 0.85, FAR was 2.96, and the building volume was around 61,410.00 m3. Meanwhile, the lowest density area was Perintis Kemerdekaan St., with BCR average was around 0.57, FAR was 0.86, and building volume was around 40,597.80 m3, then followed by the A.P. Pettarani St., with BCR average was around 0.84, FAR was 2.67, and the average building volume was around 55,321.40 m3. The condition of the ratio indicates that the area of G. Bawakaraeng St. had large buildings with large- volume buildings, moreover it had the largest land cover compared to other regions.

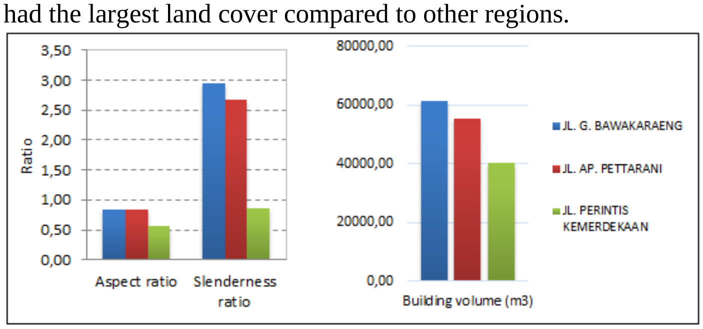

Figure 5 The comparison of densities in three urban areas

Building Materials

Building materials are explained through heavy material (HM), light material (LM), high-albedo material (HAM), and low-albedo material (LAM).

Comparison of building material characteristics in the three urban areas (Figure 6) showed that the use of lightweight materials was greater than heavy building materials and the use of materials with low-albedo value was greater than the high-albedo material. The ratio of the area of heavy building materials / volume of building area of G. Bawakaraeng St. was higher than other regions (1.30), slightly higher than A.P. Pettarani St. (1.20). Meanwhile, the ratio of the area of heavy building materials / volume of building material was in the area of Perintis Kemerdekaan St. (1.15). The highest ratio of light building material / building volume was found in the Perintis Kemerdekaan St. (1.00) and the lowest was in the area of G. Bawakaraeng St. (0.75), then followed by A.P. Pettarani St. (0.90).

In Figure 6 it was known that the three urban areas used low-albedo material rather than the high-albedo material, in other words it was still dominated by the use of dark colored materials. The low-albedo material was mostly used in the area of A.P. Pettarani St. (2.80 m^2 / 1 m^3) and the less used of low-albedo material was on Perintis Kemerdekaan St. (1.75 m^2 / 1 m^3), followed by G. Bawakaraeng St. (2.10 m^2 / 1 m^3).

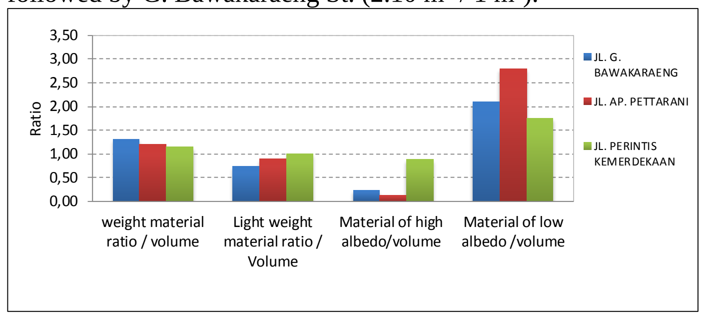

Figure 6 The characteristics comparison of building materials in three urban areas

Land cover material is explained through hard material (HM), land material with low albedo value (MLAV), and tree (T).

The comparison of the characteristics of land cover material in the three urban areas (Figure 7), showed that the use of hard land material was greater than soft land material. The highest ratio of use of hard land material was in the area of. A.P. Pettarani St (2.89 m^2 per 1 m^2 of land area), and the lowest in the area of Perintis Kemerdekaan St. (1.98 m^2 per 1 m^2 of land area), followed by G. Bawakaraeng St. (2.20 m^2 per 1 m^2 of land area).

Low albedo land material was still dominantly used in the three urban areas. Land cover material in those three regions was still dominated by dark colors. Land cover material with the lowest albedo value was widely used in the area of A.P. Pettarani St. (0.78 m^2 per 1 m^2 of land area), and the less use of land cover material with the lowest albedo value was in the area of Perintis Kemerdekaan St. (0.65 m^2 per 1 m^2 of land area), followed by G. Bawakaraeng St. (0.76 m^2 per 1 m^2 land area).

The area of A.P. Pettarani St. had the most trees compared to other regions (0.54 m^3 per environmental area). G. Bawakaraeng St. had the fewest trees (only 0.20 m^3 per area), followed by Perintis Kemerdekaan St. (0.43 m^3 per environmental area).

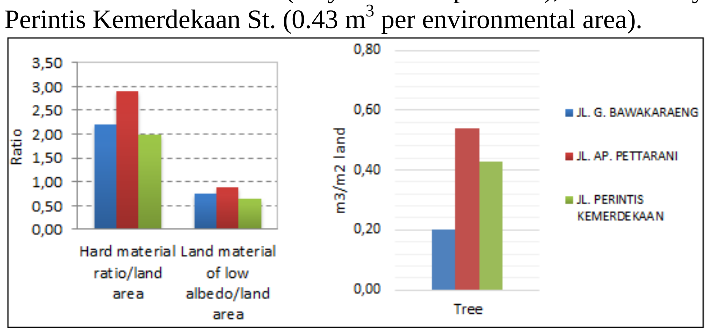

Figure 7. Land cover material in three urban areas

Landscape

The landscape was explained through elevation, contour, and distance from the coast (DC). The elevation was calculated from sea surface in meters (m). DC was calculated in kilometers (km). City area contours were calculated in the Slope Index (SI).
Comparison of the characteristics of the landscape in the three urban areas (figure 8), it showed that the area of Perintis Kemerdekaan St. was located in the highest elevation that was around 18.00 m above the sea level, its location was at the farthest distance from the coast (11.7 km), and it was the most contoured land with a slope index of (0.10). Even though the G. Bawakaraeng St. was located in the closest distance from the coast which was around 2.65 km and was located at the altitude of 2.2 m above sea level, with the lowest land slope index that was around 0.01.The area of A.P. Pettarani St. had a height of about 2.70 m above sea level with a distance of 4.03 km from the coast. The land conditions tend to be flat with a slope index was about 0.02.

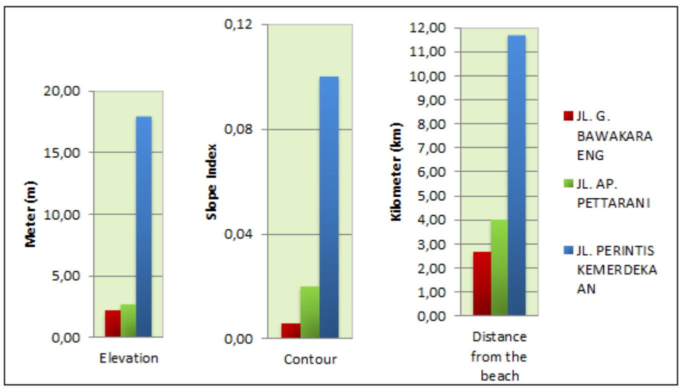

Figure 8: The comparison of landscapes in three urban areas

C. The Utilization of Local Wind

The utilization of local winds in the three urban areas is described as follows:

Wind utilization in G. Bawakaraeng St.

The measurement results of wind utilization in the area of G. Bawakaraeng St. tended to fluctuate. The highest wind speed generally occured during the day prior to the evening. The average of wind speed was about 0.93 m/sec. The highest wind speed occured at 2:00 p.m., which was around 1.77 m/sec and the lowest occured at 10:00 a.m, which was around 0.45 m/sec. This area was only able to utilize local wind speeds of around 27.24% with a wind speed ratio of around 0.27.

Wind utilization in area adjacent to A.P. Pettarani St.

The measurement results of wind utilization in the area of A.P. Pettarani St. also tended to fluctuate. The highest wind speed generally *occurred* during the day. The average of wind speed was about 1.25 m/sec. The highest wind speed *occurred* at 12.00 *a.m.*, which was around 1.80 m/sec and the lowest *occurred* at 10:00 *a.m.*, which was around 0.50 m/sec. This area was only able to utilize local wind speeds of around 36.87% with a wind speed ratio of around 0.37. The wind speed in the city area is strongly influenced by the density of existing buildings, height and distance between buildings, landscapes (distance, contour and height of an area from wind sources), the building material used is based on its ability to reflect and continue wind flow, and land cover such as tree. Trees can direct and inhibit the flow of wind speed. trees and other types of vegetation reduce the ventilation that is responsible for the wind direction [4]. Comparison of results between two situations, with and without vegetation and water pond, indicate that surface temperatures are reduced in presence of trees and the comfort is improved [5].

Wind utilization in St. Perintis Kemerdekaan

The measurement results of wind utilization in the area of Perintis Kemerdekaan St. were quite high and tended to be prevalent. The highest wind speed occured in the morning. The average of wind speed was about 1.50 m/sec. The lowest wind speed occurs at 10.00, which was around 1.82 m/sec. This area was able to utilize the local wind speeds of around 44.12% with a wind speed ratio of 0.44.

The measurement results of wind utilization in the three urban areas mentioned above shows that the area of St. Perintis Kemerdekaan had the best of wind flow. Although the utilization of local wind was still below 50% (figure 9).

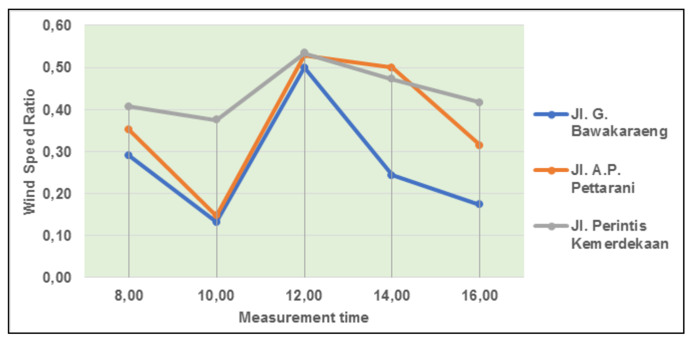

Figure 9. Wind speed of three urban areas in Makassar

Wind behavior patterns in the three urban areas were almost the same, although the locations were in different landscape. The area of St. Perintis Kemerdekaan was in the high-altitude area, A.P. Pettarani St. was in a crowded area, and St. G. Bawakaraeng was in the coastal area, hence it was a crowded area. This condition proves that the local climate could not be intervened. If the local wind speed conditions were high, then the high wind speeds could be utilized, nonetheless the amount of wind speed that could be utilized highly depended on the conditions and physical characteristics of the urban area.

I. CONCLUSION

The analysis results prove that the local winds could not be intervened. The high local wind speed contributed to the high wind speeds utilization, yet the amount of wind speed that could be utilized highly depended on the conditions and physical characteristics of the area.

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The results of this study can be used as the basis of considerations for further research related to the synergy opportunities of local wind potential and the characteristics of the physical environment to obtain a comfortable and pleasant environment. The results of this study can be used as the basis of considerations for the coastal area planners and designers for the anticipation and consideration of the local wind potential of coastal areas.

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AUTHORS

First Author – Sungkono, Universits Brawijaya
sungkono@umi.ac.id
Second Author – Sukoso, Universits Brawijaya
Third Author – Abd. Makhsud, Indonesia Muslim University
Fourth Author – Rudy Slistyono, Universits Brawijaya
Fifth Author – Juhana, Indonesia Muslim University

Correspondence Author – Sungkono, Muslim University of Indonesia, sungkono@umi.ac.id.