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Assessment of The Utilization of Local Wind in Urban Area of Makassar City Indonesia

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Abstract : The coastal area has natural and physical characteristics that are very different from the land. The coastal area has local wind potential which can be used to improve air quality in urban areas. This study aims to assess the usefulness of the wind in urban solid cashiers. This research was carried out in the city of Makassar, namely three city area locations that were selected as observation units to be studied, each with an area of 100 m. To support this research, data on wind speed and direction, and air temperature from the Makassar Potere Maritime Meteorological and Geophysical Station have been collected for five consecutive years (2012-2017). The measurement of microclimate conditions is carried out five times from morning to evening during sunny weather at the same time at all measuring points. The analysis is carried out quantitatively using a formula from Edward Ng (2006) as an indicator. The results of the analysis show that the Makassar sea breeze is very useful for planning the built environment.

Keywords : local wind, urban dense area.

Introduction

The coastal area is an open space formed naturally along the sea side. The area has physical features that vary among lands[1]. In the coastal area, sea winds go ashore during the day at around 2:00 a.m. to 6:00 p.m. by with an average speed of 2.5 - 3.5 m / s is covering to 50 km square. The land wind blows towards the sea in the afternoon at 24.00 - 07.00 a.m. One of the coastal cities in Indonesia is the Makassar, located in South Sulawesi. Makassar is the capital of South Sulawesi, which is the center of economic activity from various surrounding areas, and is the center of economic activity in eastern Indonesia. The city is inhabited by more than 1.7 million people. It is also known that Makassar is a city that is quite wide, which is around 36.1 km, with an area of 175, 77 km^2.

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Sea breeze in the city of Makassar was still able to reach the area well at a distance of 10-20 km from the sea, but did not get a significant obstacle to the surface being passed[2]. The speed and smoothness of wind movements in urban environments are very dependent on the shape of the topography, physical conditions and existing vegetation[2]. The previous results suggest that building forms, elevation and slenderness are needed in determining the smooth flow of wind in the built environment[3]. Very heterogeneous forms of urban buildings make analytical descriptions of wind flows in urban areas very difficult. Wind flow in urban environments is governed by a variety of complex factors, such as diverse building geometry, impingement flow, separation and recirculation and local thermal effects. The situation is even more complex in urban canopy layers, where streets cause complex canyoning effects that depend heavily on the orientation of the canyon with respect to incoming wind. Many researchers have investigated various aspects of urban flow [4;5;6;7], but currently there is no study focus on the hot spot area.

In the city of Makassar there are two large rivers (Tallo river and Jenneberang River) a canal that connects the inner city with the sea. These potentials enable stream of coming wind to the city. Tello river area with delta and its river branches are swamp areas, mangrove forests and ponds that are still very large (1,456 ha), this condition enable to drain the wind from the sea without obstacles. This potential needs to be utilized well to improve the microclimate and create a comfortable environment in the urban area.

Based on data from the Pottery Maritime Meteorology and Geophysics Station 2006-2011, the average wind speed in Makassar is around 2.29 m / s. Based on the information in this section, you can find locations that have specific locations for improving air quality in urban areas. Unfortunately, urban planners are affected by the beach's local wind needs. Natural strength elements are not much anticipated and ordered by city planners or designers. Evaluation of wind characteristic and usage potential inside the city needs to be done as information for sustainable city design strategies. This research aims to assess the usefulness of the wind in several hot spots of the dense city.

Experimental

This study uses a quantitative method with a field case approach to assess local wind utilization in urban dense areas. Empirical data were collected through field observations with recording techniques and direct measurements. Local wind speed and direction data were collected from the Makassar Potere Maritime Meteorology and Geophysics Station for five consecutive years (2012-2017). Wind speed data in urban areas are obtained through direct measurements carried out at three observation locations as the dense city hot spots. These included urban areas around G. Bawakaraeng Street (approximately 1 km from the coastline), A.P. Pettarani St. located in city center (approximately from the coastline), and Perintis Kemerdekaan St. (approximately 20 km from the coastline) determined by consideration: 1) is in a diverse landscape (near the coast, the middle of the city, far from the coast, 2) is in a zone of sea wind reach (maximum 50 km from the coast), 3) located in dense urban areas. The measurement time was determined based on the circulation of the sun and the hours of solid activity, at 8 a.m, 10 a.m, 1 a.m, 2 p.m and 4 p.m. Measurements were made during sunny weather at the same time at all measuring points.

The local wind speed of the city of Makassar was analyzed through two steps. The first step, local wind speed mapped the conditions and patterns of behavior every month throughout the five-year period in the form of graphs, so that the potential benefits can be seen. The second step, the local wind speed that blows into the city area can be known its usefulness by calculating the influence of buildings and plants that can direct the wind by using the wind speed ratio formula as an indicator [8], as follows:

$$VR_W = \frac{V_p}{V_\infty} \quad \text{.......................................(1)}$$

Note:

VR_w = wind speed ration indicated by the occurrence of building and vegetation

V_∞ = monthly average local wind speeds (m/s)

V_p = wind speed at measurement points (m/s)

Results and Discussion

1. Local wind speed and direction

Figure 1 showed the average wind speed conditions in Makassar. Wind speed was quite high, which ranges from 3 m/s in January in the rainy season, slightly decreased to 2.1 - 2.5 m/s sec after the dry season enters in March to October, then raised again in December in the rainy season. The average wind speed in 2012-2016 tends to decrease, which is at an average speed of 2.4 m/sec (figure 2).

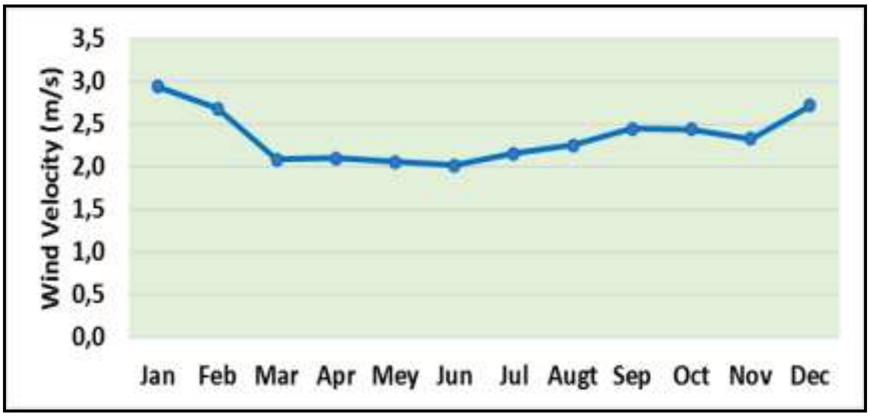

Figure 1. Graph of average monthly wind speed from 2012-2017 in Makassar

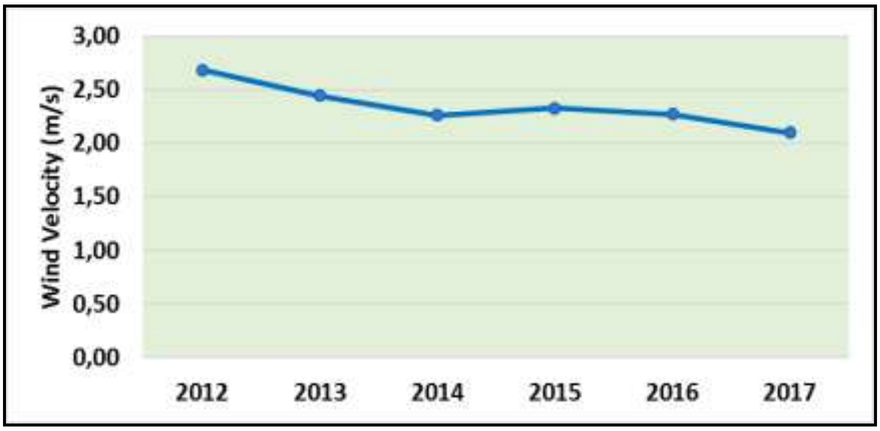

Figure 2. Average wind speed graph from 2012-2017 in Makassar

According to data from BMG Maritime Potere Makassar, the highest wind direction and the greatest speed are from West (W) and Northwest (NW) directions. This condition tended to follow the occurrence of sea wind patterns, considering the Makassar Strait is on the W and NW sides of the Makassar City (Figure 3). During the rainy season the wind direction generally comes from the direction of NW, whereas in the dry season it generally comes from the direction of W.

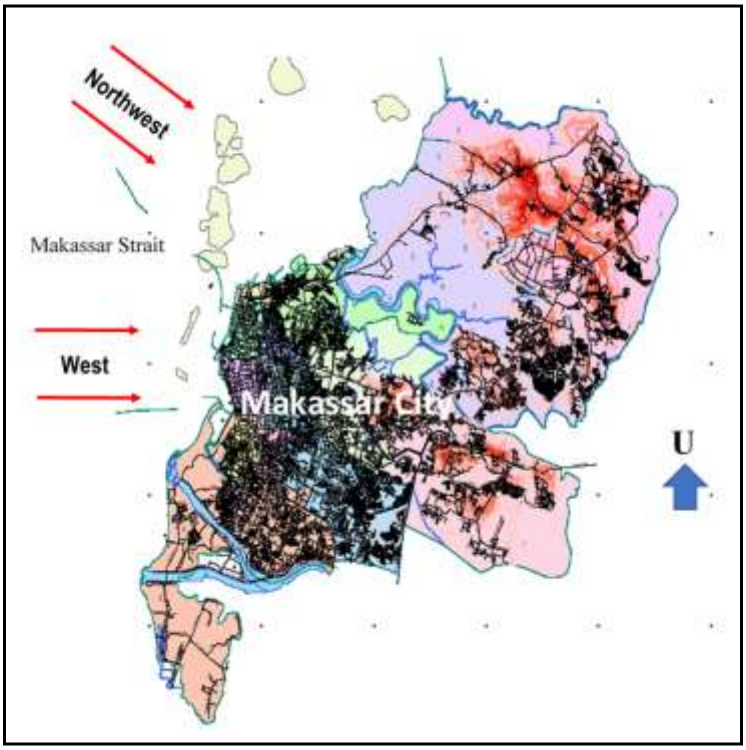

Figure 3. The highest wind direction with the greatest speed in Makassar

Based on local wind speed data from 2012 to 2017, the result showed that it was considered quite high, which averages around 2.4 m/sec. Therefore, this condition was very possible to be used to improve air quality in urban areas. Building in the city of Makassar began to grow and develop from the direction of the coast. Buildings are lined up along the coast, growing in layers with a dominant road pattern in the form of a grid. The shape and arrangement of buildings along the coast is the face of the city from the sea, so it can be a shield as well as a city vent.

Makassar City has a coastline length of about 36.1 km with a height that varies between 0-25 meters above sea level. This condition can result in a pattern of wind movements as shown in figure 4.

Figure 4. Wind movement patterns in the coastal area

2. Wind speed conditions in the urban area of Makassar

The results of wind speed measurements in three urban areas during the rainy season (Figure 5) and drought (Figure 6) showed that the average wind speed in the area of Perintis Kemerdekaan St. is 1.5 m/s (rainy season) and 1.26 m/sec (dry season)) This value was much higher than the area of A.P. Petarani St. 1.25 m/s (rainy season), 0.99 m/sec (dry season) and the area G. Bawakaraeng St. 0.91 m/sec (rainy season), 0.78 m / sec (dry season). Wind movement patterns in the three observation locations both in the rainy and dry seasons are almost the same starting from morning to evening, except that wind speed levels vary greatly from one location to another (Figure 7 and Figure 8)

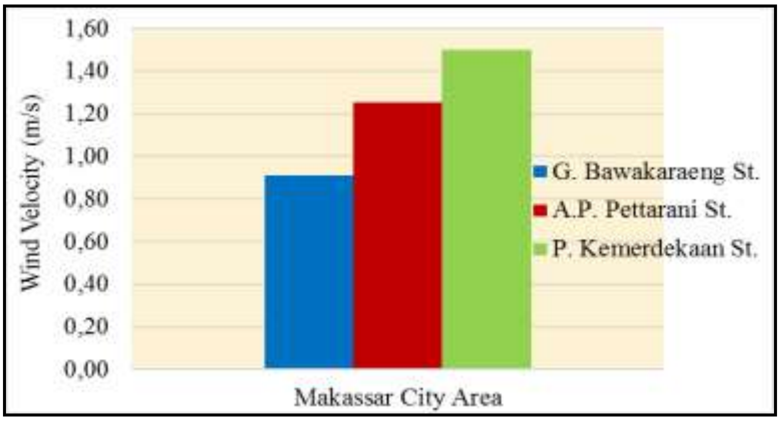

Figure 5. Wind speed in three urban areas during the rainy season

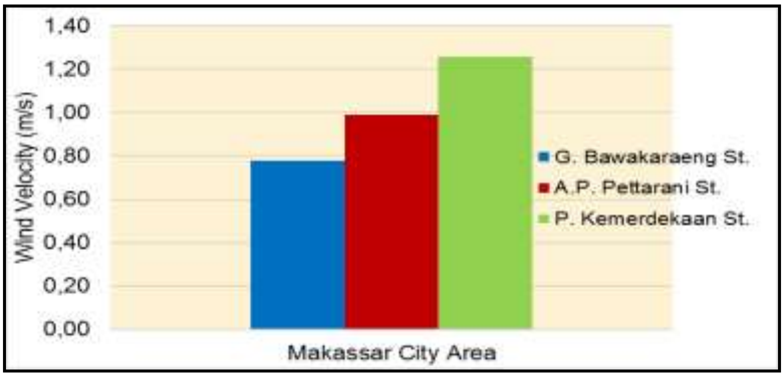

Figure 6. Wind speed in three urban areas during the dry season

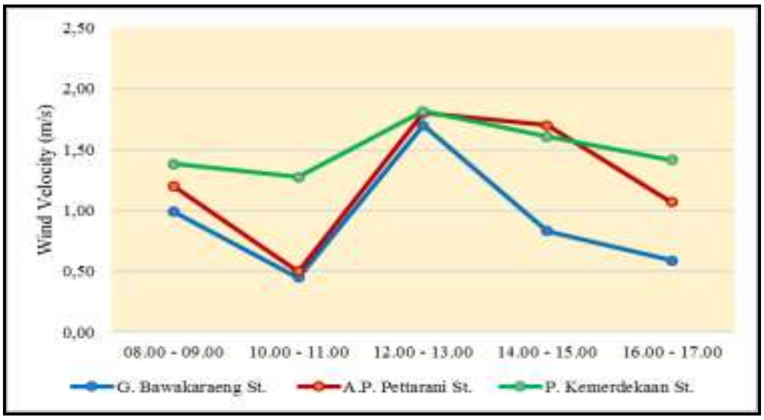

Figure 7. Wind speed from morning to evening in three urban areas during the rainy season

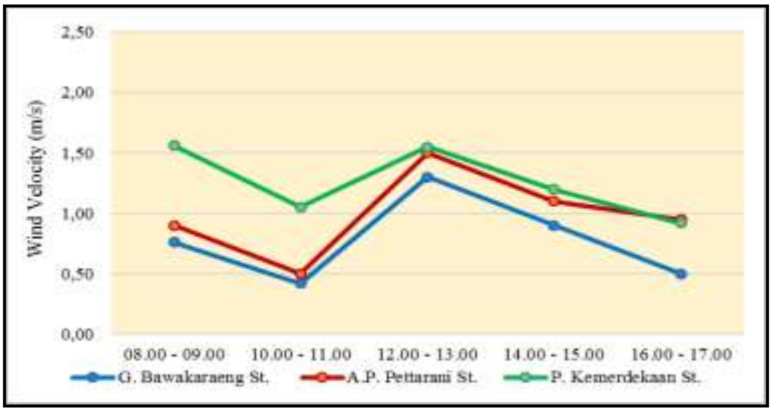

Figure 8. Wind speed from morning to evening in three urban areas during the dry season

3. Assessment of wind utilization in the urban area of Makassar

Wind speed that blows in the city area can be known by calculating the wind speed ratio using a formula[8], by calculating how much influence buildings and plants can direct the wind to the urban area by using an indicator of the wind speed ratio (VRw), wind speed in boundary layer which is not affected by surface roughness ($V\infty$), and wind speed at the road level (height of measuring point 2m) as an impact of surface roughness (Vp). The calculation results gave an illustration that the higher the VRw value, the lower the wind movement resistance caused by buildings or plants. The high or low wind speed ratio is influenced by the smoothness or inhibition of wind movements caused by buildings or plants. This means that the urban area wind speed observed is determined by the surface roughness of the area. Benefits of wind in the area of G. Bawakaraeng St.

The results of the measurement of wind usefulness in the area of G. Bawakaraeng St. showed that the local wind speed level that reaches this location tends to change. Higher wind speeds generally occurred in the afternoon before the afternoon. The average wind speed is around 0.93 m/sec. The highest wind speed occurred at 2 p.m., which is around 1.77 m / sec and the lowest occurs at 10 a.m, which was around 0.45 m / sec. This area is only able to utilize local wind speeds of around 27.24% with a wind speed ratio of around 0.27.

In this area based on observations along data collection from morning to evening, the biggest wind direction and most come from the West (B). Figures 9 and 10 showed that the speed and extent of wind dispersion zones in the area of G. Bawakaraeng St. tends to change. Wind speeds in the rainy season tend to be higher and the spread zone was wider than the dry season. However, it speeds above 1.3 m/s is considered low, at 39.49% in the rainy season and only 31.33% in the dry season. Wind speeds in each zone might increase or decrease in size during the rainy and dry seasons due to the influence of physical characteristics of the environment in response to climate change.

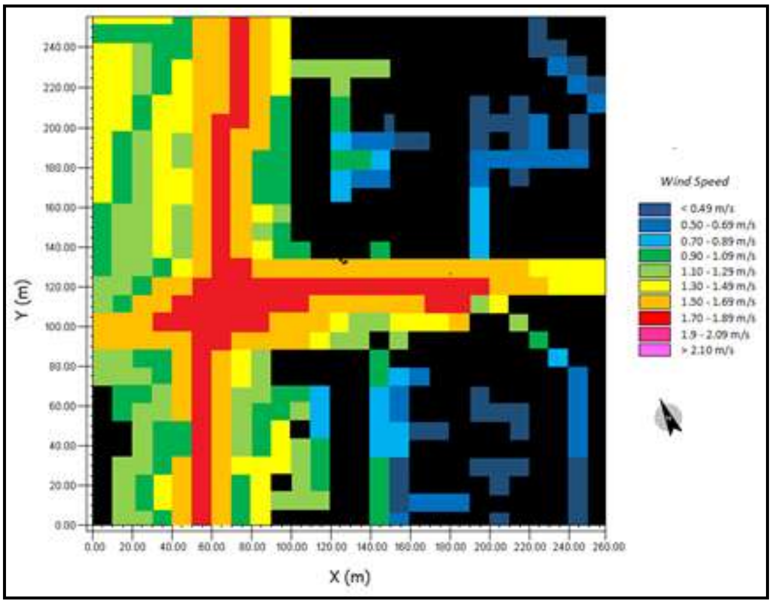

Figure 9. Wind speed and spread in the area of G. Bawakaraeng St. in the rainy season

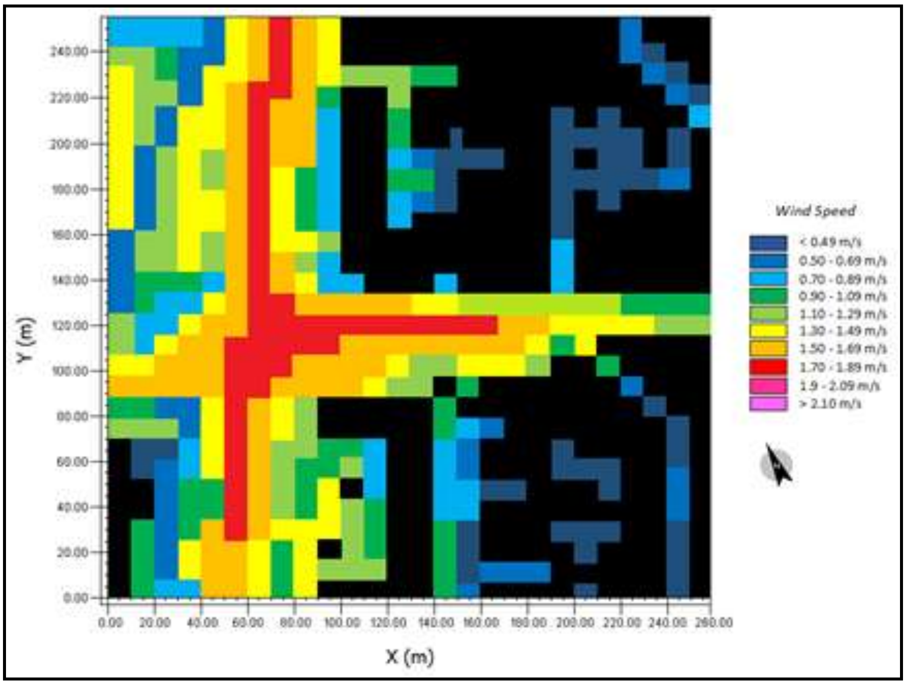

Figure 10. Wind speed and spread in the area of G. Bawakaraeng St. in the dry season

The results of the measurement of wind usefulness in the area of A.P. Petarani St. showed that the local wind speed level that reaches this location tends to change. Higher wind speeds generally occurred during the day. The average wind speed is around 1.25 m/sec. The highest wind speed occurred in 12.00, which is around 1.80 m sec and the lowest occurs at 10:00, which is 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.

In this area based on observations along data collection from morning to evening, the biggest wind direction and most come from the North West (NW). Figures 11 and 12 showed that the speed and extent of wind dispersion zones in the area of A.P. Petarani St. in the rainy season tends to be higher and the spread zone is also wider than the dry season. The area of wind speed above 1.3 m / s ranges from 48.48% in the rainy season and 36.34% in the dry season, this value is higher than G. Bawakaraeng St.

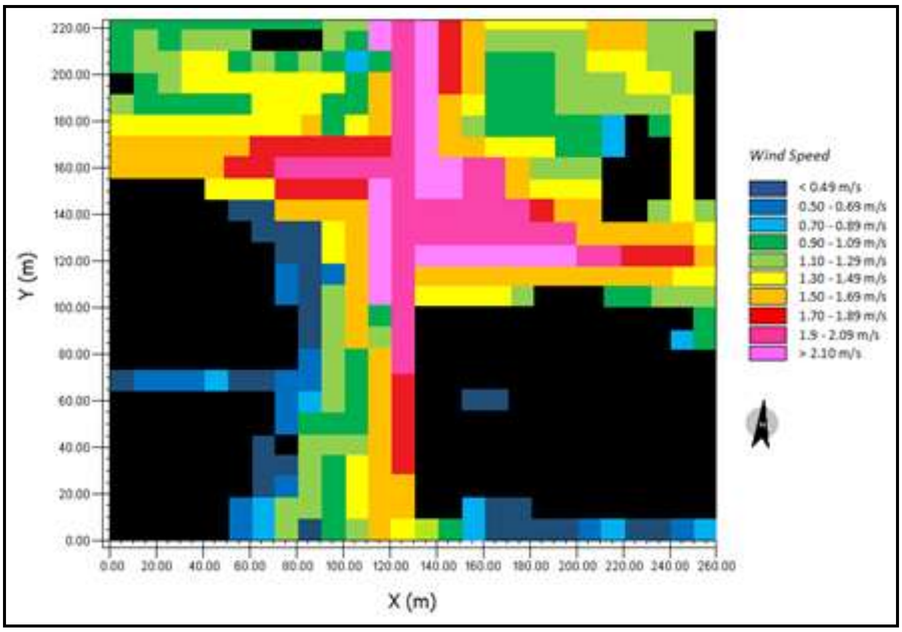

Figure 11. Wind speed and spread in the area of A.P. Petarani St. during the rainy season

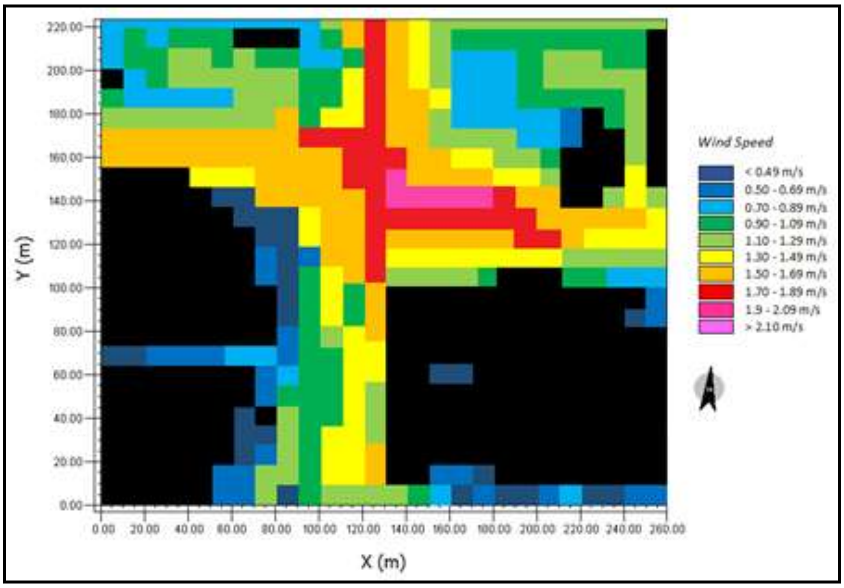

Figure 12. Wind speed and spread in the area of A.P. Petarani St. during the dry season
The benefits of wind in the area of Perintis Kemerdekaan St. The results of the measurement of wind usefulness in the area of Perintis Kemerdekaan St. showed that the local wind speed level that reaches this location is quite high and tends to be evenly distributed. The highest wind speed occurred in the morning. The average wind speed is around 1.50 m/sec. The highest wind speed occurred at 10 a.m., which is around 1.82 m / Sec. This area was able to utilize local wind speeds of around 44.12% with a wind speed ratio of around 0.44

In this area based on the results of observations as long as data collection from morning to evening is almost the same as the A. P. Pettarani St., that is, the biggest wind direction and most are from the North West.

Figures 13 and 14 show that the speed and extent of wind dispersion zones in the area of Perintis Kemerdekaan St. is better than the other 2 locations, but the conditions are almost the same because the wind speed in the rainy season tends to be higher and the spread zone is wider than the dry season. Wind speeds above 1.3 m/s area of zones are still below 50%, which is 49.70% in the rainy season and only 37.68% in the dry season.

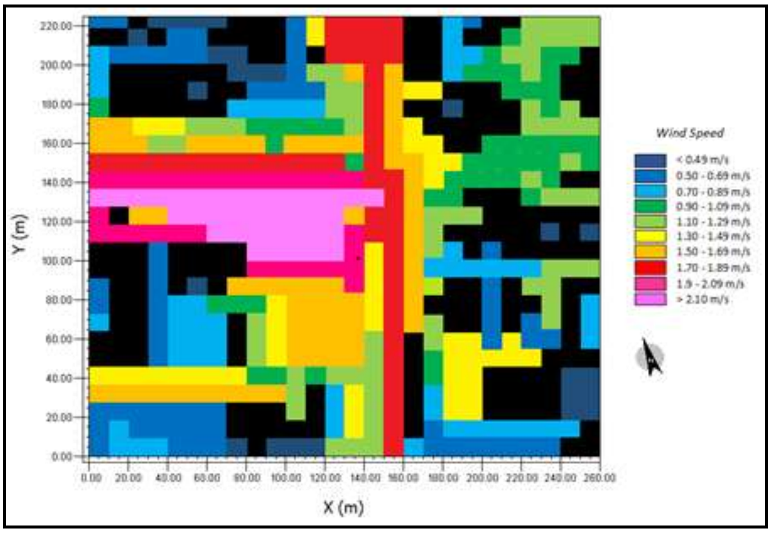

Figure 13. Wind speed and spread in the area of Perintis Kemerdekaan St. in the rainy season

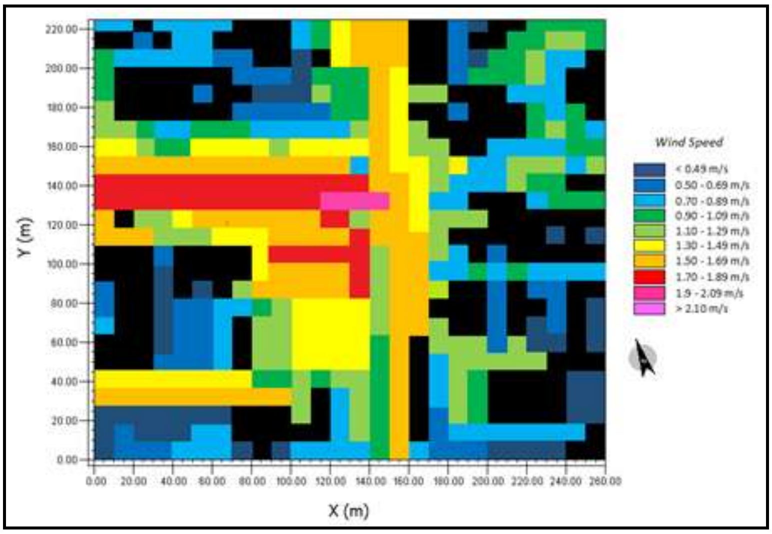

Figure 14. Wind speed and spread in the area of Perintis Kemerdekaan St. in the dry season with different physical characteristics of the environment, the level of local wind utilization in the 3 observation locations also varied. The results of the measurement of wind usefulness in the three urban areas indicated that the area around Perintis Kemerdekaan St. was the best flow of wind (figure 15).

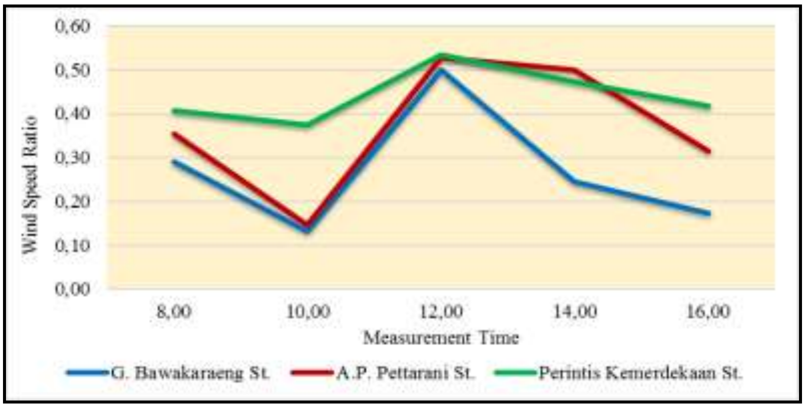

Figure 15. Wind speed of three urban areas in Makassar

The behavior pattern of the winds of the three urban areas is the same observation location even though the location is in different landscapes. Perintis Kemerdekaan St. area is in the elevation area, A.P. Pettarani St. is located in a crowded city area, and the area of G. Brokering St. is located on a coastal area, but is high density. This condition proves that the local climate cannot be intervened. If the local wind speed conditions are high, then the high wind speed can be utilized, but the wind speed magnitude that can be utilized is very dependent on the conditions and physical characteristics of the existing urban area. The usefulness of the wind speed that reaches the three observation locations is also determined by the existence of tall buildings that can block or direct the wind from the sea to the city area. Around the area G. Bawakaraeng St. is ± 1 km from the coastline, there are 23 tall buildings above 6 floors that have the potential to block or direct the wind from the direction of BL. area A. P. Pettarani St. is ± 4 km from the coastline, there are 41 tall buildings above 6 floors that have the potential to block or direct the wind from the direction of BL, B and BD. Meanwhile, around the area Perintis Kemerdekaan St. is ± 20 km from the coastline, there are 43 tall buildings above 6 floors that have the potential to block or direct the wind from directions B and BD.

Figure 16 showed that around the area Perintis Kemerdekaan St.from the West and Northwest direction still have ponds, swamps, and vacant land that allows the wind to move smoothly. Beside that, there is also a big river (Tello river), so it is very possible for the breeze way effect. The same conditions occur around

A.P.Pettarani St. there are still vacant land and canals (Pampang canal), while the area G. Bawakaraeng St. was located in a city area that is already dense with buildings, even though the location is close to the beach.

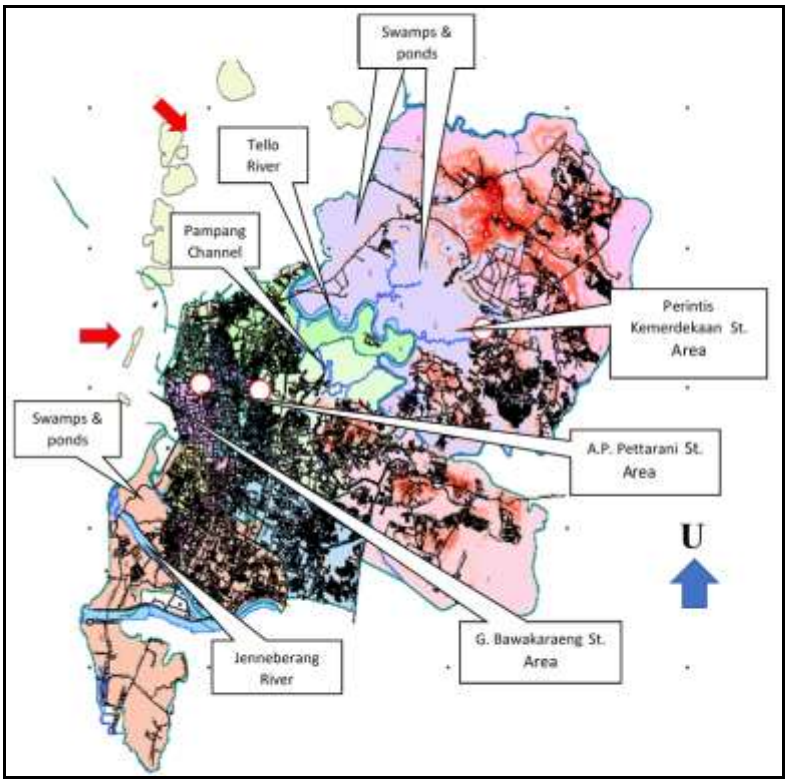

Figure 16 Condition of the Makassar city area and position of the observation location

The results showed that wind speed increased in areas farther away from the coast, but with relatively lower levels of veils and buildings. The Perintis Kemerdekaan St. area which is in the Tello river path obtains the high speed wind because the river lane allows more free wind movements. The Bawakaraeng area has the lowest wind speed because it is filled with tall and dense buildings. Measurement of daily wind speed shows that during high season wind speeds during the day while in the dry season high wind speeds in the morning and afternoon.

High wind speeds during the day have the potential to disentangle the effects of heating on UBL (urban boundary layers). This layer is defined as the lowest atmospheric layer affected by soil, known as, which hosts various ecosystems, including human activities. This layer through heat exchange, momentum, species and moisture between the surface and atmosphere occurs, which in turn determines the microclimate, pollutant / contaminant dispersions and hydrological cycles[9]. High wind speeds during the day can be utilized to the maximum extent possible by opening windows to buildings and buildings, reducing traffic density and reducing human activity outside buildings. Low wind speed in the morning can be used to maximize human activity because the temperature in the morning is still lower than during the day. In other studies, a decrease in temperature can be done by increasing the increase of green roof coverage[10]. In addition, urban vegetation planting is effective in reducing high heat levels, stormwater buffering, and healthy fostering and a friendly living environment, especially for arid cities[11;12]. The main mechanism of cooling of vegetation is by changing the partition of surface energy through enhanced evapotranspiration. In addition, the presence of green belt can provide shade to the road, building walls, and partial roofs, which are cooled built by the environment through direct interception and radiant heat exchange[13,14]. Urban greening has an impact on the mall environment in urban canopy layers (more or less from the ground to the average roof level) by modifying land surface energy and water transportation, which in turn modulates the thermal environment in urban boundary layers[10].

Conclusion

The results of the analysis show that the local winds of the Makassar coastal area are very potential to be utilized mainly by the sea breeze, but the local wind cannot be intervened. If the local wind speed condition is high, then the high wind speed can be utilized, but the wind speed magnitude that can be utilized is highly dependent on the conditions and physical characteristics of the existing area. The results of this study can be input for further research related to opportunities for synergy between the potential of local wind and the characteristics of the physical environment to improve air quality in urban areas. The results of this study can be input for coastal planners and designers to always anticipate and consider the local wind potential of the coastal area.

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