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KEMENTERIAN HUKUM DAN HAK ASASI MANUSIA

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IV.	Jenis Ciptaan	:	Karya Tulis
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Variations of UV Radiation Intensity in Manado and Surrounding

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Abstract- This study presents the the variation of ultraviolet irradiance in coastal and mountainous areas in the city of Manado and surrounding. Measurements were made during the six months between July and December 2012. The research results demonstrated that the UV irradiance value varies due to changes of sun position to equator and the difference of altitude, cloud cover, and land surface cover material.

Keywords*- ultraviolet, irradiance, albedo*

I. INTRODUCTION

Ultraviolet radiation is a part of electromagnetic radiation, which has a wavelength range between 100 nm to 400 nm. In the scheme of the electromagnetic radiation spectrum, ultraviolet radiation lies in left of visible radiation. Ultraviolet radiation has a higher frequency and shorter wavelength than the visible radiation. Based on the source of radiation, ultraviolet radiation can be distinguished as a natural UV and artificial UV. Naturally, ultraviolet radiation from the sun to produce vitamin D in the skin [1]. The usefulness of ultraviolet radiation in the medical field, food processing, and other fields, encouraging the creation of ultraviolet radiation generating devices such as ultraviolet lamp. Ultraviolet radiation is used for purification and removing bacteria from drinking water [2], reduction of contaminant gases such as carbon dioxide [3], preservation and packaging of food [4] ; Based on the benefit and the dangers of ultraviolet radiation exposure, the ultraviolet radiation is classified into three bands namely UV-A (400-315 nm), UV-B (315-280 nm), and UV-C (280-100 nm) [1;5].

Total natural ultraviolet radiation reaching the Earth is composed of approximately 95% of UV-A and UV-B 5% (Wikipedia). Ultraviolet radiation with higher frequency (UV-C) blocked by the ozone layer. Ozone absorbs more radiation energy at higher frequencies such as UV-B and UV-C [6]. The total ultraviolet radiation that reaches the earth's surface includes the direct component (direct radiation from the sun) and a diffuse component of the solar radiation. Diffuse components consists of dissipated (stattered) radiation by the atmosphere, clouds and the environment (atmosphere, clouds and the surroundings) [6]. Contribution of diffuse component to the total ultraviolet radiation that falls on the Earth's surface ranges from 30 to 75 percent. This large variation indicates that the variation of atmospheric and environmental factors significantly influence the acceptance of ultra-violet radiation in various places on the surface of the earth. Turner and Parisi suggested that ultraviolet radiation albedo donated by snow is between 50 to 60%, sand 10 percent, and grass 2 to 3 percent. Turner and Parisi (1980) also found a reduction in the intensity of UV-A can reach 80% at 13:00 and UV-B about 70% at 2 pm [7].

Factors that affect the total ultraviolet radiation received by the earth's surface [1; 6] is: 1) the angle of sun elevation (solar elevation angle or height of the sun above the horizon, 2) The annual variations in the earth-sun distance (latiitude) 3) chemical conditions such as atmospheric ozone layer 4) cloud cover, 5) reflecting power of the surface associated with land cover, 6) altitude above sea level. Correa and Ceballos suggests the factors that determine the total ultraviolet radiation at the earth's surface include: a) the meteorological, such as temperature, wind fields, and cloud coverage, b) geographical, such as latitude, longitude, and altitude; c) astronomical, related to the seasonal, and daily sun position; and d) physical, such as total ozone content and aerosol characteristics (aerosol type, burden and optical depth) and the surface albedo [8]. El-Nashar et al suggested that the increase in the concentration of chemical pollutants in the atmosphere causes a decrease in the intensity of UV radiation at the Earth's surface [9]. Environmental factors with the varies of albedo to contribute the intensity of UV radiation received by the sensor on the surface of the earth. The albedo (reflecting power) is the ratio of the reflected to the incident energy. The albedo varies by the characteristics of reflecting surface materials and the wavelength of radiation. Chadyšiene and Girgždys noted the albedo in UVA wavelength range for grass is 2%, water 7%, and sand 13%. Albedo in UVB wavelengths range for grass is 2%, water 5%, and sand 9% [10]. Correa and Ceballos cites Castro et al. suggested that albedo of asphalt around 2 to 7% and concreate 10 to 20%[11]. The greater albedo to cause the greater of increasing of UV radiation at the earth surface. Chadyšiene and Girgždys cites Long, (2006), states that for the albedo of 10% and 50% the increasing of UV intensity will be 3% and 24% respectively[10]. This suggests that environmental conditions and the surface materials variations caused the difference in UV intensity at the locations on the earth surface.

Ozone depletion in the stratosphere influence on the changes of ultraviolet radiation penetration in various places on the earth's surface. Increasing of UV radiation due to reduced concentration of ozone in the stratosphere to encourage the various studies on protecting or reducing the impact of UV radiation [12]. Based on the results of measurements carried out in the United States between 1974 and 1985, Scotto et al, found that there has been an increase in UVB due to changes in atmospheric conditions, climate and environment[13]. McKenzie et al suggested that from 1980 to the end of the 21st century, UV-B radiation will decrease by 5-20% at the middle to high latitudes, and will increase 2-3% around the equator [14]. Based on calculations, Bais et al, argued that in 2090 the ultraviolet radiation will be reduced approximately 12% at high latitudes and increase of approximately 1% in tropics [15]. Monitoring the intensity of ultraviolet radiation on the earth's surface is increasingly important, especially for the prevention of various diseases such as skin cancer [16], and the life of aquatic biota [17].

This preliminary study is aimed to measure and determine the intensity of UV radiation as well as daily variations in North Sulawesi. Measurement of daily fluctuation of ultraviolet radiation performed for six months, between July 2012 and December 2012. Locations were selected based on a variation of the height above sea level and the land surface cover. Measuring the UV radiation intensity at each position performed on two weather conditions, at bright and cloudy. The information obtained through this study is the pattern of daily changes of ultraviolet radiation intensity, comparison between radiation at mountain and coastal area, the influence of the environment (vegetation etc) and cloud cover on the intensity of ultraviolet radiation. These preliminary results provide a reference monitoring changes of ultraviolet radiation in North Sulawesi, Indonesia.

II. METHOD

Generally researchers perform measurements at wavelengths range of UVA and UVB radiation. Parisi and Kimlin , Kolb et al., Chadyšiene and Girgždys [6,18,10] , measure the of natural UV radiation in the wavelength range of the UV-A (320-390 nm of) and UV-B (280-320 nm). Chadyšiene and Girgždys (2008) measure the radiation intensity and surface albedo using a handy radiometer UV-A radiation - 365HA, with the spectral response of 320-390 nm and a handy PMA2201 UVB, with spectral response of 280-320 nm[10] . Effects of Natural Intensities of Visible and Ultraviolet Radiation on Epidermal Ultraviolet Screening and Photosynthesis in Grape Leaves1

Measurement of ultraviolet radiation in the wavelength range of the UV-C was not performed beca use of the intensity of radiation at the earth's surface is very low. Tavakoli and Shahi (2007) measure the UV radiation in the range of 100-400 nm and found that the ground-level UV-C intensity is very low[19].

This study measures the intensity of UV radiation in the wavelength range of UV-A and UV-B, UV-meter using the detector spectrum: 290-390 nm. This research was conducted in four positions with different surface conditions. The first position is located in open coastal areas (Boulevard Manado Beach). Surfaces are covered with asphalt and tall buildings around it within 50 to 60 m from the measurement position. The second position is vegetated coastal areas (Kalasey village). Surfaces are covered with grass and tall trees around the position of measurement. The third position located in the mountainous area, about 800 m above sea level. Measurement position located in a residential area with much closed distance between house buildings. The surface covered by asphalt, soil and grass. The fourth position is located in Manado State University campus, about 830 m above sea level. The surface covered by grass and high trees at surroundings. From the measurement position, there are high buildings with the distance more than 70 m. Measurements at each site performed in two variations of atmospheric conditions i.e. sunny conditions and cloudy. Measurements were conducted during the six months between July 2012 to December 2012. It is intended to measure changes in the intensity of UV radiation due to changes in latitude. Measuring the ultraviolet radiation at each site performed in simultaneously with the measuring of the intensity of visible radiation. Measurements performed twice every week with adjusted to atmospheric condition: cloudy and clear sky. Measurement of the intensity of visible light using a hand lighmeter with a maximum range of 20,000 lux. Measurement of ultraviolet radiation using a UV meter with detector spectrum between 290-390 nm. UV meter have the two range of measurement i.e. the low range from zero to 1999 $\mu W/cm^2$ and the high range from 1999 $\mu W/cm^2$ to 19990 $\mu W/cm^2$. The UV radiation intensity measured and expressed in units of $\mu W/cm^2$. The measured UV intensity is the total UV (UVA and UVB) radiation diffusion that is comprised of direct and reflected radiation by atmospheric particles and the surface of the earth.

III. RESULTS AND DISCUSSION

A. Monthly changes of maximum irradiance of UV

The results of measurements at four locations showed that highest monthly radiation intensity occurs in July and lowest in December. The highest UV irradiance are: `424 μW/cm2 in Kalasey beach, 430 μW/cm2 in Boulevard beach, 438 μW/cm2 in Tomohon and 439 μW/cm2 in Manado State University (UNIMA) campus. The lowest values of UV irradiance (in Desember) are 394 μW/cm2 in Kalasey Beach, 399 μW/cm2 in Boulevard Beach, 404 μW/cm2 in Tomohon and 404 μW/cm2 in UNIMA campus. The percentage of irradiance reduction from July to December at the fourth location of measurement ranges between 7.07% to 7.97%. The results of these measurements indicate that the value of UV irradiance varies significantly according to sun position from the equator [6]. In July, the position of the sun is nearest to North Sulawesi latitude, while in December, the sun's position shifted farthest to the south. The result is consistent with the results found by Hu et al, which take measurements of UV radiation in Beijng[20] .They found the higher intensity on March and lower intensity on December. In March the sun position is closest to the latitude of Beijing, while in December the sun position is in the farthest distance. Physicaly, these results to show the phenomena of energy absorbtion by atmospheric particles which directly proportion to the distance [6].

B. Daily pattern of UV and visible radiation changes

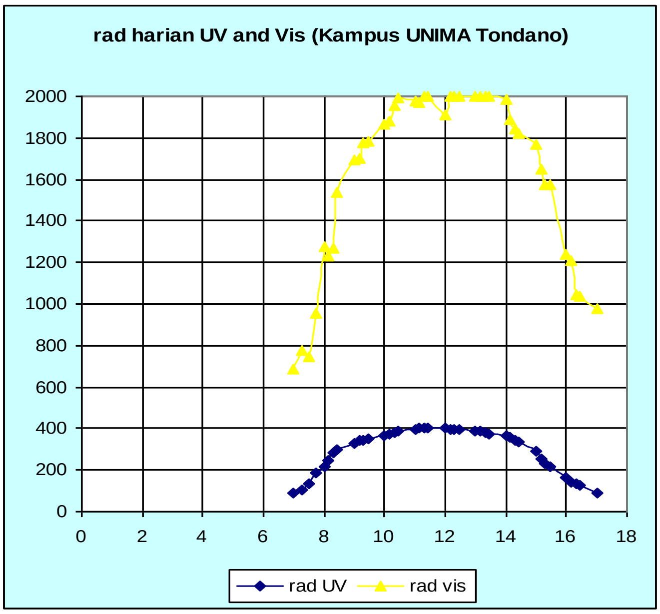

Figure 1. a. Daily pattern of UV and visible radiation changes

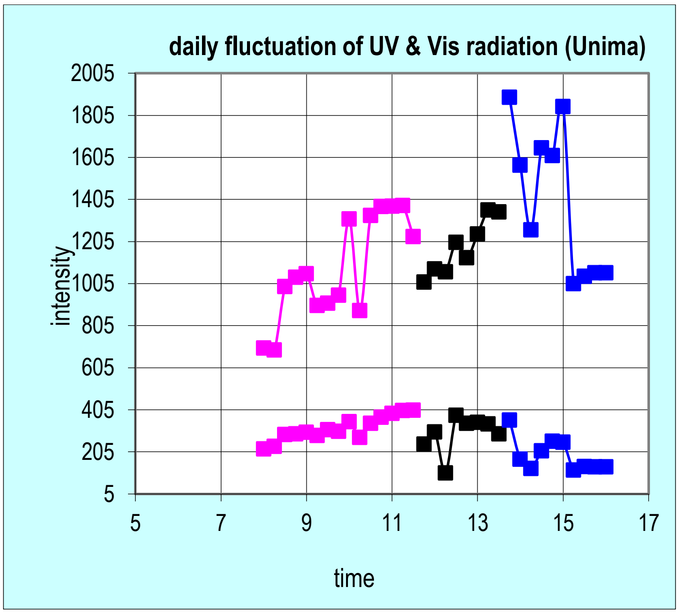

Figure 1. b. Daily fluctuation of UV and visible radiation due to cloud cover

Figure 1a shows the daily changes of UV and visible radiation intensity recorded using the UV and lightmeter repectively, mounted in UNIMA Campus. The ordinate represents the intensity while the abscissa represent the time of observation. The UV radiation intensity presented as the irradiance (μW/cm2) and the visible radiation intensity presented in lux. Figure-1.a. shows the pattern of daily changes in the intensity of UV radiation (blue color) together with the pattern of changes in the intensity of visible radiation (yellow color). The pattern of daily changes in both graphs follow the sun's position changes. The steepest gradient of UV and visible intensity changes occurred around 08.00 to 10.00 (increase) and between 15.00 to 16.30 (decrease). Between 11.00 to 14.00, the UV and visible radiation intensity was relatively constant. The peak value of UV irradiance was 378 μW/cm2 occurs at 12.30. The pattern of UV radiation changes as described by Parisi and Kimlin , Diffey, Chadyšiene and Girgždys [6,5,10] . The peak value of visible radiation was 1354 lux occurred at 13.15 hours. At that time the thin clouds cover the sky. The pattern of daily changes of visible and UV radiation intensity is also the same for the other three observation sites. The result of measurement in Boulevard Beach shows the peak value of UV irradiance was 375 μW/cm2 occure at 13.15 and visible radiation was 1998 lux occurs at the same time. The peak of UV irradiance in Kalasey Beach, was 326 μW/cm2 occurred at 13.00. The results of this study indicate that the peak of UV irradiance varies between locations due to differences in cloud cover and environmental conditions. These results are consistent with the results of previous studies by Koepke and Mech and Chadyšiene and Girgždys [21,10] .

The detailed daily changes of UV and visible radiation intensity was presented in Figure 1.b.

Figure-1.b. shows the change of UV and visible radiation intensity due to cloud cover changes (results of measurements on UNIMA campus, dated July 24, 2012). When the sky was bright between 08:00 to 09:00 the two graphics increase and then decreased due to thin cloud cover between 09.15 to 09.45. Between 10.45 to 11.30 the sky was clear, and the two graphics increased again. The UV and visible graphics sudently drops at 11.45 and still low until 12.15 due to thick cloud cover. At 13.45 the sky was clear and the intensity of UV and visible increased again. Furthermore, solar radiation was cover by thin and thick clouds alternately so that the graph of radiation intensity fluctuates up and down. The examples of graphic as presented in figure 1a and figure 1.b. to show that the main factors determine the daily fluctuation of UV and visible radiation intensity were the sun inclination and the cloud cover.

C. UV variation according to the altitude above sea level

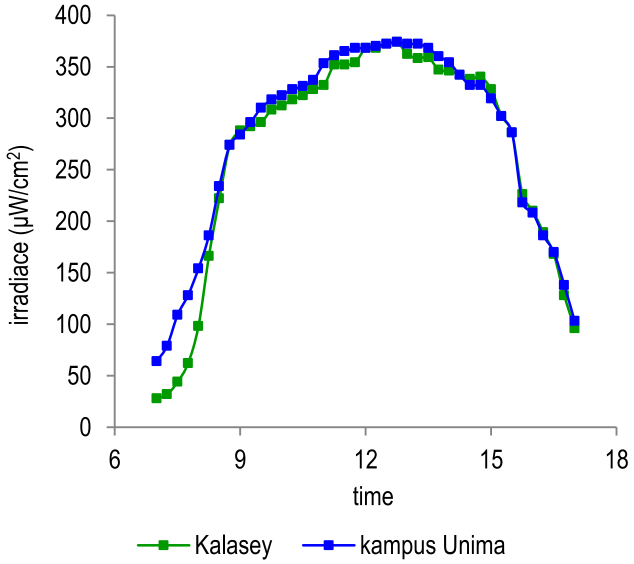

Figure 2. Daily changes of UV radiation at coastal (Kalasey) and mountaneous area (Kampus Unima)

Figure 2 shows the graph of daily changes of UV and visible radiation intensity at vegetated beaches (Kalasey Neach) and at the mountainous areas (830 m above sea level) which is on the campus of UNIMA - Tondano. Both graphs generated from data measure on the same day ie on August 24, 2012. During the measurement the sky was bright. The measurement result reveals that in the morning, the intensity of UV radiation at the beach Kalasey significantly lower than the intensity of UV radiation on the campus of UNIMA. During the day, the intensity of UV radiation at the Kalasey Beach slightly lower than the intensity of UV radiation on campus of UNIMA. In the afternoon, the intensity of UV radiation at the two locations was almost the same. The difference of radiation intensity in the morning was caused by tree shadowing on sensor in Kalasey Beach while in campus of Unima, the sun shines fully. During the day, where the intensity of direct radiation increased sharply, the intensity of the radiation received by the sensor in the Campus of UNIMA slightly higher than the intensity of UV radiation received by the sensor at Kalasey Beach. This difference can be understood with regard to height differences above sea level. Height differences associated with differences in the distance of the sun to the earth's surface. Increasing in sun distance to the earth's surface was proportional to the increasing of energy absorption by atmospheric particles. Lower energy absorption at higher position causing the intensity of radiation received by sensor was higher than at the lower position. These results are consistent with the results of Parisi and Kimlin (1997) which states that the intensity of UV radiation at a higher place greater than in the low or close to sea level [6]. Land surface is almost the same at both locations, covered by grass, so it can be concluded that the differences were due to differences in altitude

D. Cloud cover effect on UV radiation intensity

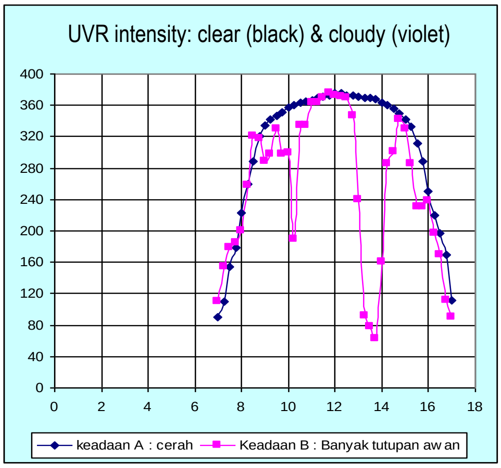

Figure 3. a. UVR at open coastal area

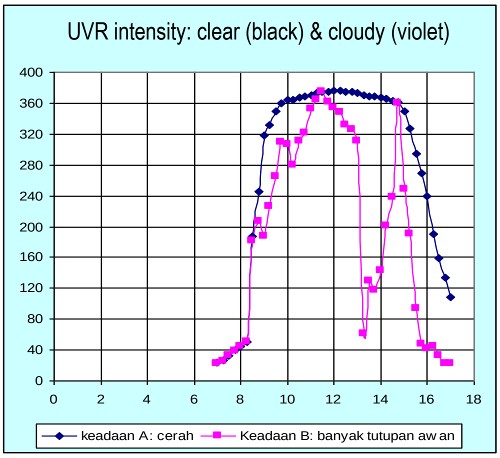

Figure 3. b. UVR at vegetated coastal area

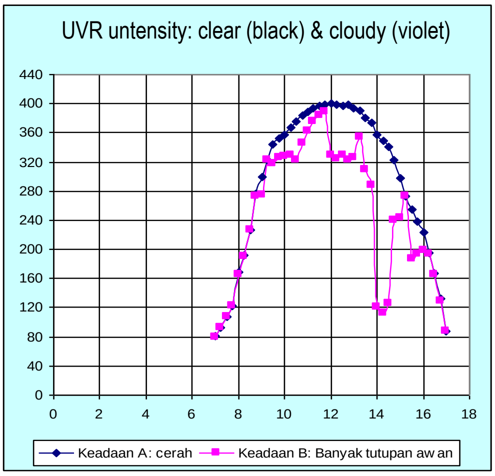

Figure 3. c. UVR at mountainous/seatlement area

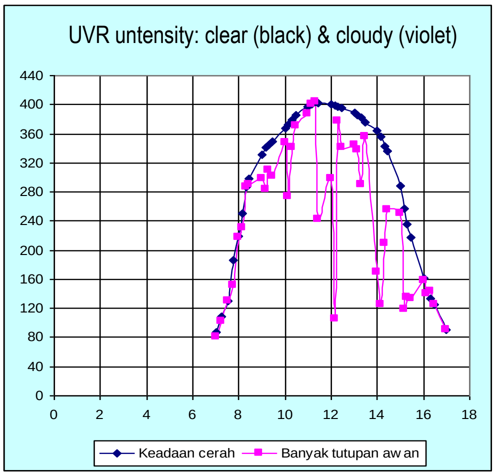

Figure 3. d. UVR at vegetated mountain area

Figure 3a to 3d show the UV irradiance fluctuations due to changes in cloud cover at the four study sites. Black color graph shows the results of measurements of UV irradiance value in bright atmospheric conditions. Violet color graph shows the UV irradiance fluctuations due to thin and thick cloud cover. Two groups of data presented on each figure was the result of the measurement in the different day but the difference was not more than one week. The difference of two groups of data can be assumed not affected by the shift of sun position to the equator. It means that the difference between the two graphs was caused by the differences in cloud cover. The research results showed that when the thick clouds covered the sun, the decreasing of UV irradiance to reach 96% of the value of irradiance at the same time without cloud covers. These results was agree to the research results found by Estupinan and Raman [22], but slightly higher than Kolb et al. [19] that found the maximum reduction as 80 %. These results differ significantly from the results of measurements by Wang et al, in Central China that record the maximum reduction of 65% [23] . This difference can be expected partly due to differences in the inclination of the sun and environmental conditions (atmospheric and earth surface materials). Maximum reduction of UV irradiance was occurred around 10.00 to 15.00; this time was agree to the previous research by Kolb et al.; Wang et al, [19;23] . Physically this is due to the high intensity of direct radiation during the day. When the direct radiation blocked by cloud, the intensity of the radiation drops drastically. In the morning, the intensity of direct radiation relatively low and the irradiance value contributed by atmospheric and earth's surface albedo. Effect of cloud cover to the total irradiance was low in the morning.

E. Comparison between vegetated and open coastal area

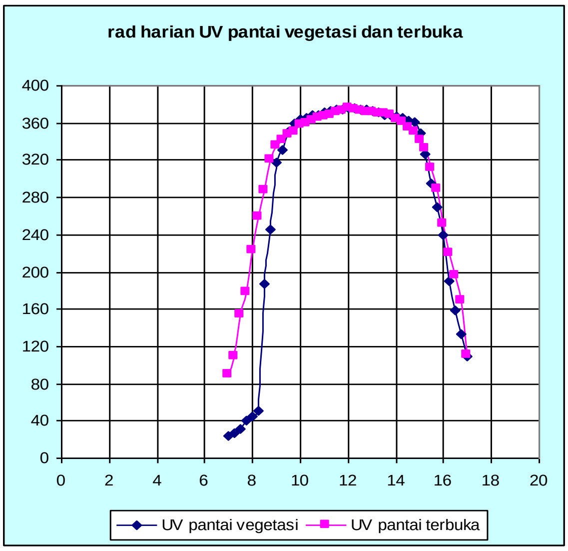

Figure 4. UVR intensity at open (violet) and vegetated coastal area (black)

Figure 4 shows a comparison of the intensity of UV radiation changes in vegetated coastal areas (Kalasey Beach) and the open or not vegetated coastal (Boulevard Beach). The graph shows that in the morning until 09.00 hours, the intensity of UV radiation in coastal vegetated areas is lower than in the open beach covered asphalt surface. This difference is caused by the sun was blocked by the trees in the Kalasey Beach, while not in the Boulevard Beach. Contributions of asphalt and concrete albedo in the Boulevard Beach higher than vegetation albedo, also influence the total irradiance at the Boulevard that higher than at Kalasey Beach. At noon until the early afternoon, the intensity of radiation at the vegetated and not vegetated beaches almost the same. This was due to the dominance of the direct radiation is almost the same at both locations. In the afternoon, the intensity of UV radiation in vegetated beach slightly lower than in the not vegetated beach. In the afternoon contribution of UV radiation albedo by the Earth's surface to increase again due to the reducing of direct radiation intensity. These results coincide with the results of previous studies by Parisi and Kimlin; Castro et al.; Chadyšiene and Girgždys; Turner and Parisi [6;11;10;77] , who concluded that the intensity of UV radiation affected by the arth surface material lbedo. In this study, the land surface materials and the environment in the coastal Boulevard (asphalt, water and concrete) have a higher albedo than the grass that covers the land surface at Kalasey Beach.

IV. CONCLUSION

Results of natural UV irradiance measurements in the city of Manado and surrounding areas indicate that the maximum irradiance at each location change due to the distance of the sun or the sun's position toward the equator. Daily changes of UV radiation intensity at each location of measurement to follow the change of sun inclination. In clear skies (sunny days) condition, the maximum radiation intensity occurred around 13:00 local time. The different elevation of measurements position above sea level shows a different intensity of UV radiation. The maximum UV irradiance is slightly higher at the higher position. The intensity of UV radiation also depends on the type and composition of the material at the land surface. Vegetation-covered surface shows the lower albedo of irradiance than surfaces covered by asphalt with adjacent surface of water and concrete buildings. At each location, the UV radiation greatly fluctuates depending on cloud cover. The measurement results indicate that cloud cover can cause a reduction in irradiance values up to 96%. The large reduction of UV irradiance values occur between 10.00 to 15.00. Further research needs to be done i.e. measuring the irradiance variations of UV-A and UV-B, measuring the variation of albedo of the various surface materials, etc...

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