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ANALYSIS OF RAIN WATER ACIDITY IN PADANG CITY

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ABSTRACT: The fast growth of population, the increased flow of transportation, industry spread in Padang Municipality, and thermal inverse effect can trigger air pollution leading to acid rain in the municipality. The aims of this study are to analyze the nitrate, sulfur and pH contents of rain water and to analyze the effect of rain intensity, air temperature, air pressure, and wind direction and speed on the acidity of rain water in Padang Municipality. The study was conducted using a field measurement and a laboratory test. The sample of rain water was collected by a purposive sampling technique as displayed in *Thiessen* polygon. The sample of rain water was collected in ten times of sampling in six regions of *Thiessen* polygon in Padang Municipality. The data collected were analyzed by climate data analysis, rain intensity analysis, multiple linier regression analysis, spatial analysis, and descriptive analysis. The results of the laboratory test showed that sulphate and nitrate contents in rain water in Padang Municipality was still under the threshold of clean water quality No. 416/MENKES/PER/IX/1990, i.e. 400 mg/l for sulphate and 10 mg/l for nitrate. The effect of rain intensity on the acidity of rain water was inversely proportional to sulphate and nitrate contents and directly proportional to pH. The results of validation test and multiple linear regression analysis about the effect of sulphate, nitrate, and pH contents and independent variable as the selected factor displayed in classic assumption test showed that sulphate and pH contents had a significant effect, while nitrate content had no significant effect

Keywords: Acidity, Rain, Sulphate, Nitrate, pH Regency

1. INTRODUCTION

Rain out is one of the indicator of air pollution. The cause of rain out is Sulfuric and Nitrogen oxide compounds that enter into the atmosphere and deforming into Sulfuric Acid and Nitric Acid. These compounds combine with Hydrogen Chloride, which then fell together as rain out [1]. Some gases such as sulfur dioxide (SO_2), Nitrogen Dioxide (NO_2), Hydrogen Sulfide (H_2S) and Carbon Monoxide (CO) always released into the air as a by-product of natural processes such as volcanic activity, decay of garbage, living things, and forest fires. Besides caused by natural pollution, air pollution can also caused by human activity [2].

Air pollution will affect the acidity or alkalinity level of the rain that falls into earth [3]. Normally uncontaminated rain water's pH is about 5.6 so it is slightly acidic. This is because the dissolved Carbonic acid (H_2CO_3) that formed from CO_2 gas in rainwater. This Carbonic acid is a weak acid so that the pH of rain water is low. If the rain is polluted by strong acid, then the pH of rain that falls below 5.6,known as rain out.

The nature of the acidity and alkalinity of rain water that falls into the earth's surface caused by several factors, including the intensity levels of the released pollution, the state of meteorological air when it rains, how far the distance from the pollution source, and when the rain reaches the earth's surface. The intensity level of pollution in the air is affected by several factors that are natural factors and factors that caused by human activity. The natural factors that caused the air pollution can be neutralized by the nature within a certain time limit, but the human activity becomes the largest contributor to air pollution through industrial activity and road transport which the intensity and the quality increase every day [4-5]. The impact of the emissions released by motor vehicles and industry is smoke that contain SO2 which cause the forming elements of rain out. Sulfur compounds which is the air pollution gas are sulfur oxides (SO_2, SO_3) and H_2S gas. Sulfur oxides produced by fuel combustion of motor vehicles, industrial smoke, and the burning coal [7-10].

The meteorological circumstances include the intensity of rainfall, the humidity, the wind speed, the wind direction and the intensity of solar radiation plays an important role in affecting the spread of contaminants in the air. Sometimes the air is quite clean, very polluted. In some circumstances, the shape of the earth's surface will affect the spread of contaminants. The cities that surrounded by hills and adjacent to the coast.

2. METHODS

This research was conducted in the Padang

city, West Sumatra Province. The method used in this research is the field measurements and laboratory testing. The field measurements were carried out, among others, rainfall intensity, pH, temperature, humidity, air pressure, wind direction and speed, while laboratory tests are conducted, among others, sulfate content and nitrate measurements contained in rain water [11-13]. The rain water's sampling use the purposive technique that shown in *Thiessen* polygons. The sample of rain water taken within 10 times in 6 region in *Thiessen* polygon at Padang. In addition to the primary data, the secondary data which supporting this research were obtained from BMKG, Bapedalda, BPSDA, and BPS Padang. The data analysis included the climate data analysis, rainfall intensity analysis, multiple linear regression analysis, spatial analysis and descriptive.

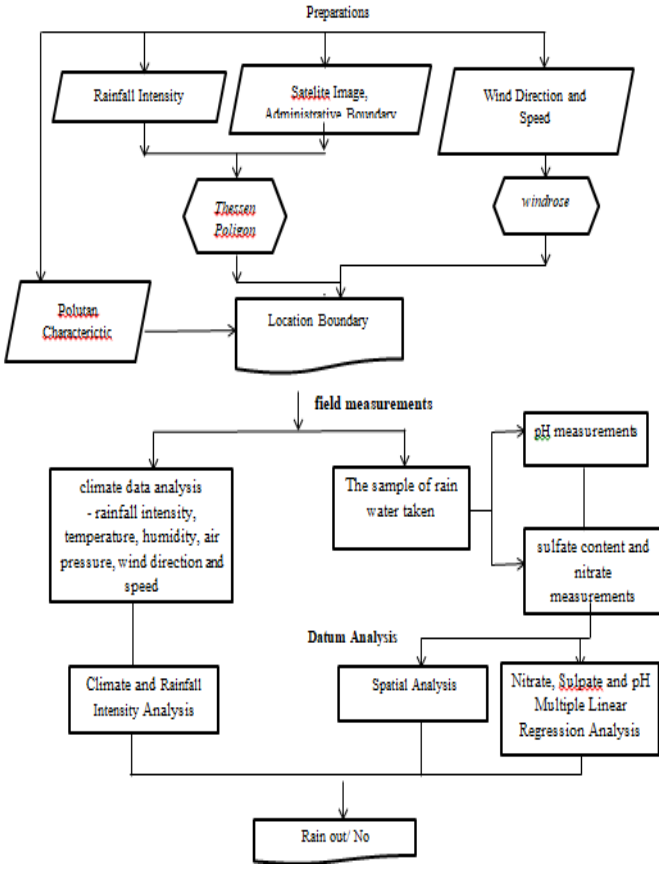

Figure 1 Research flow chart

3. RESULTS AND DISCUSSION

3.1 The role of each independent variables and the the most influential independent variables on the sulfate content that contained in rainwater

Based on the results of classical assumption test including normality test, multi colinearity, autocorrelation and heterokedasitas, the variables that affect the sulfate content in rainwater at Padang city are the time of rains, rainfall intensity, temperature, humidity, air pressure and wind speed, feasible for the multiple linear regression analysis. The equation results for the sulfate content in rainwater as follows:

$$Y_{SO4} = 16{,}4 - 0.173\ t - 0.85\ I + 0.098\ T\ H - 0.016 - 0.003 - 0.148\ P\ S$$

Table 1. The renewable coefficient value (beta) of each independent variables with sulfate as the dependent variable

No	Indept Variable	(*beta*)
1	Time of rains	-161
2	Rainfall intensity	-280
3	Temperature	0,318
4	Humidity	-0,45
5	Air pressure	-0,29
6	Wind speed	-460

Source: Results Analysis of Authors, 2015

Table 1. presents the independent variables

data with the renewable coefficient value or beta value to determine the most influential independent variables to the dependent variables in a multiple linear regression equations that were analyzed. From the data in a row of the most influential independent variable (the largest Beta value) until the independent variables that has the lowest influence (the smallest Beta value). Independent variables that most influential on the sulfate content in rainwater are wind speed (S), rain intensity (I), and the timing of rainfall (t) with a beta value of -460, -280,-161. The low intensity of rainfall and the time of rain in the morning when the air temperature is still low means the ability of water to dissolve the solute is low, so the concentration is high. Based on the renewable coefficient (beta), the multiple linear regression equation for the sulfate content in rainwater at Padang city is:

$$Y_{SO4} = 16,4- 0.173\ t - 0.85\ I -0.148\ S$$

2. The role of each independent variable and the most influential independent variable on the pH value contained in rainwater

Based on the results of classical assumption test including normality test, multi co-linearity, autocorrelation and heterokedasitas, the variables that affect the pH level in rainwater at Padang city aretime of rainfall, rainfall intensity, temperature, humidity, air pressure and wind speed, feasible for the multiple linear regression analysis. Results of the equation for the pH level in the rainwater as follows:

$$Y_{pH} = 139.2 - 0.43\ t + 0.107\ Ih - 0.21\ T + 0.02\ H + 0.137\ P + 0.081$$

The Role of regression constant value and regression coefficients of each independent variable on the addition or subtraction calculations of dependent variable in the multiple linear regression equation as follows:

1. The regression constant value in that equation of 139.1 has role, if all the variables in the equation are considered constant, in other words there is no influence of the time of the rainfall, rainfall intensity, temperature, humidity, air pressure and wind speed to pH value is 139.1.
2. The regression coefficient of the time of rainfall (t) is - 0.43. This t is the time of the rain which is divided into morning, afternoon and evening. This division is based on the change in the meteorological elements that significant to the time of the rain. According to that, then the division is categorized into morning with the number 1, afternoon with the number 2 and evening with number 3. The regression coefficient of -0.43 has role, the earlier time of the rain fall, the pH level is lower, otherwise if the rain falls in afternoon or evening , then level of pH increase by 0.43 mg/l.
3. The regression coefficient of rainfall intensity (I) is +0.107 has role, each enhancement of 1 mm/hr of rainfall intensity will increase the pH level in rainwater as much as 0.107 mg/l. Otherwise, each reduction of 1% of intensity of rain will reduce the pH level in rainwater by 0.107mg/l.
4. The regression coefficient variable of temperature (T) is -0.21 has role, each temperature reduction of 1 degree will increase pH level of 0.21 mg/l. Otherwise, each enhancement in temperature of 1 degree will reduce the pH level of 0.21 mg/l.
5. The regression coefficient of humidity (H) is +0.002 has role, every 1% reduction in humidity will reduce the pH level of 0.002 mg/l. Otherwise, each enhancement of 1% of humidity will increase the pH level in rain water of 0.002 mg/l.
6. The regression coefficient of pressure (P) is +0.137 has a role, each enhancement of pressure of 1 Hpa will increase the pH level in rainwater by +0.137. Otherwise each reduction of pressure of 1 Hpa will reduce the pH level in rainwater of 0.137 mg/l.
7. Wind speed regression coefficient (SS) is +0.081 has role, each reduction of 1 knot of wind speed, the pH level in rainwater decrease by 0.081. Otherwise, each enhancement of wind speed of 1 knot, the pH level in rain water will increase by 0.081 mg/l.

Table 2. The renewable coefficient value (beta) of each independent variable with pH level as the dependent variable

No	In dp Variable	Renewable coeff (*beta*)
1	Time of rains	-0,52
2	Rainfall intensity	0,454
3	Temperature	-0,089
4	Humidity	0,04
5	Air pressure	0,317
6	Wind speed	0,327

Source: The results of the analysis, 2015

Based on the renewable coefficient (beta) in Table 5.14, then the multiple linear regression equation for pH as follows:

$$Y_{pH} = 139.2 - 0.43\ t + 0.107\ Ih - 0.21\ T$$

The laboratory test results showed that the sulfate and nitrate content in rainwater at Padang

city is still below the standard quality of clean water NO: 416/Menkes/Per/IX/1990, the amount is 400 mg/l for sulfate and 10 mg/l for nitrate.

3. Spatial Analysis

Based on the results of laboratory tests and field measurements of meteorological elements that carried out in May and June 2015, it can be concluded that the highest sulfate content is located in area with low rainfall intensity and the meteorological circumstances that occurred during the rain. The rainfall intensity that is lower compared to the other locations and the times of rain that is longer than other areas makes pollutant elements in rainwater joins with the small amount of water, so the pollutant is in high concentrations. It can be concluded that the air temperature is inversely proportional to the humidity. This is in line with the concept of atmosphere pressure that the air pressure will decrease by 1mb of every 10-meter increase in altitude. The wind direction and speed will determine the deployment and the distribution of pollutants in the air.

The rain that fell in the morning, tend to have low level of pollutant concentrations because the air temperature reaches the minimum limit while the humidity reaches the maximum limit, and in the morning the temperature difference between land and sea are high and makes the wind that blows hard too. The opposite situation occurred during the day, where the temperature reaches the maximum limit while the humidity reaches the minimum limit so that the levels of pollutants combined in low rainfall intensity, consequently the level of pollutants that measured is also high.

The highest nitrate content in rain water is located in the area around the main street where the pollutants come from motor vehicles emitted. The high to low of nitrate content in rainwater is also influenced by the rainfall intensity and meteorological conditions including the temperature, humidity, air pressure, air humidity, wind direction and speed.

The degrees of acidity and alkalinity of a substance is known as pH. The highest level of pH in rainwater in this study tends to be found in the whole area of sampling. Although there are differences, but the differences are not too significant compared with the degrees of acidity of rainwater which is still consider in the water quality standard. The pH has a proportional relationship to the rainfall intensity and humidity, whereas the higher the rainfall intensity and the humidity percentage are, the higher the pH will be. While the air temperature is inversely proportional relationship to pH, it means that the higher the temperature is, the lower the pH will be.

4. CONCLUSION

According to the results and discussion, the results of this study can be summarized as follows: 1) The results of laboratory tests showed that sulfate and nitrate content in rainwater at Padang city still below the quality standards that set by the Regulation of the Minister of Health NO: 416/Menkes/Per/IX/1990, it is 400 mg/l for Sulfate and 10 mg/l for Nitrate; 2) Based on the multiple linear regression, the variable that affects the concentration of sulfate are the time of rainfall, rainfall intensity, temperature, humidity and wind speed, while the concentration of nitrate in rainwater has small value and low correlation with the rainfall intensity and meteorological conditions such temperature, humidity, air pressure, wind direction and speed; 3) The pH value that contained in rainwater, indicates a value below the rain out's threshold, that is 5.6. The pH value is determined by the equilibrium between anions and cations that is contained in rainwater, because the nature of the acid and alkaline of a substance is determined by chemical reactions include acid gas phase reaction, liquid phase neutralization and the washing process; and 3) The shorter the periods of rain is, the greater the intensity will be. The rains sometimes stop and being smaller or weaker, so if the duration of the rainfall is long, then the intensity is relatively small. Variation in rainfall in the local scale is influenced by the characteristics of the topography. Variation in rainfall in the highlands is higher than in the lowland areas. In general, the rainfall enhance with the increasing of altitude. Based on the research results and the conclusions above, the authors suggest that the analysis of the atmosphere dispersion capabilities will be very useful in the spatial patterns and its allocation, including the application of the "buffer zone" concept which is add resed to manage the air quality as a result of emission sources and in industrial areas especially residential area around PT. Semen Padang can be done by controlling the emissions from its industrial activity, and population's residents distance towards the west which is the opposite direction of the wind.

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