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Geostatistical Analysis of Plastic Waste Disposal to Ecosystem (Vegetation) in Kefamenanu of North Central Timor Regency

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ABSTRACTS

The research was conducted in June – July 2017, in Kefamenanu of North Central Timor District. Number of locations of plastic waste contamination used as research sites were 44 (forty-four) points. The samples in this study were 4 points of plastic waste disposal. The objectives of this research are: 1) to geostatistically mapping soil pH, soil moisture, air temperature and humidity of area contaminated by plastic waste disposal in Kefamenanu, 2) to know which species are found in research location, 3) to understand statistically the relationship between accumulations of plastic waste to vegetation density in Kefamenanu. The methods used in this research are: 1) data collection of plastic waste dumping point by using GPS. The location is expressed in latitude and longitude coordinates; 2) sampling method was purposive sampling. The analysis of vegetation is quantitative analysis, and quadratic method was used for research implementation of terrestrial vegetation. The observed data were analyzed in the following ways: a) Geostatistical map of the area was generated from ArcGIS 10.4 software, b) Calculating density parameters, and c) Statistical analysis using t-test for two independent means.The study revealed that From inferential statistical analysis through t-test, it cannot be proved that there is a difference in vegetation density between accumulated and not accumulated plastic waste sites because the number of samples analyzed is very small. Statistically descriptive through the calculation of the mean (also illustrated in the mean graph), there is a difference in the mean of the density of vegetation (either absolute density or relative density) between the accumulated and non-accumulated plastic waste sites.
Keywords: geostatistical analysis, vegetation density, plastic waste
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1. Introduction

Technological advances in Indonesia that drive large numbers of people or large industries to use plastic packaging have grown enormously. This development in addition to benefiting the welfare of the community has also become a problem now caused by how to manage the garbage cans and plastic. The existence of inorganic waste such as cans and plastics has flooded every corner of urban areas even rivers and lands that have polluted the environment.

Plastics are long molecular chain polymers typically made of carbon, hydrogen, oxygen and or silicon, which are chemically linked together or polymerized (Halden, 2010). The properties of plastics and organic materials are very different. (Rees, 1980) explains that plastic is estimated to decompose perfectly within the soil takes 100 to 500 years. (Surono, 2013) explained that plastic waste is very negative for the environment (ecosystem) because it cannot decompose quickly and can reduce soil fertility. Dumps of waste from domestic waste can disrupt or contaminate the soil due to leachate (garbage water), odors, and estates. Heaps of garbage also cover the soil surface so that the land cannot be utilized. (Mattina *et al.*, 2003) explains that the direct impact of a pollutant is often considered more hazardous although the indirect impact of accumulation of contaminants may eventually cause considerable damage. So the pollution impact on plants is not only caused by high concentrations of pollutant but with low concentrations (below the threshold) and if accumulated in a relatively long time and continuously can also cause damage to the plant. The existence of plastic waste also affects the ecosystem (vegetation) surrounding environment. If the plastic waste is thrown away to the open environment, it will affect the density of vegetation plants around the environment. Based on preliminary observation at the research site by the researcher, it is seen that the location filled with plastic waste is not dominated by plants.

Kecamatan Kota Kefamenanu is one of the districts located in North Central Timor District. Based on Statistical Data of the Office of Population and Civil Registration of North Central Timor District in 2016, the population of Kecamatan Kefamenanu City is 47.972 people (Badan Pusat Statistik Timor Tengah Utara, 2016). This increase in population is assumed to be the cause of increasing plastic waste productivity in Kota Kefamenanu Subdistrict every year.

It is observed that most of the dryland in Kefamenanu City is used as agricultural land and home-scale plantations as well as parks. This means that food needs in limited stock are sourced from the land. If the pile of plastic waste in the dryland soil is not controlled, then it is predicted that the increasing accumulation of plastic can cause great environmental degradation of dryland in terms of soil quality in the future in this area. This study aims to geostatistically mapping soil pH, soil moisture, air temperature and humidity of area contaminated by plastic waste disposal in Kefamenanu; to know which species are found in research location, and to understand statistically the relationship between accumulations of plastic waste to vegetation density in Kefamenanu.

2. Materials and Methods

2.1. Materials

The tools used in this study are: a) Camera to photograph the waste disposal site and photograph the species observed in the field, b) GPS (Global Positioning System), c) Roll meter to measure the area of research, d) Compass to determine the starting point of observation, e) Med-line to measure the diameter of the stem at each level of stake found in the study site, f) Soil Tester, which is used to measure soil pH and soil moisture at each point of the study site, g) Thermo-hygrometer to measure air temperature and humidity at each point of the study site.

The materials used in this study are: a) Writing station to write and record data or results in the field and also record the waste disposal site, b) Some plastic ropes to draw transect lines and observation plots, c) Plastic bags to fill any unknown plant samples at the study site for identification, d) Paper labels, used to mark every species observed.

2.2. Method

2.2.1. Data Collection

All plastic waste disposal site was recorded using GPS (Global Positioning System) and the data was expressed in latitude and longitude coordinates. It was observed that the plant level of trees and poles are not influenced by plastic waste at the study points. Therefore, the plants at the level of seedlings and saplings were examined. Fachrul et al. (2007) suggested that the quadratic method is used as a unit of measurement value in the analysis of vegetation. Sampling area with its plot and transect are shown at Figure 1.

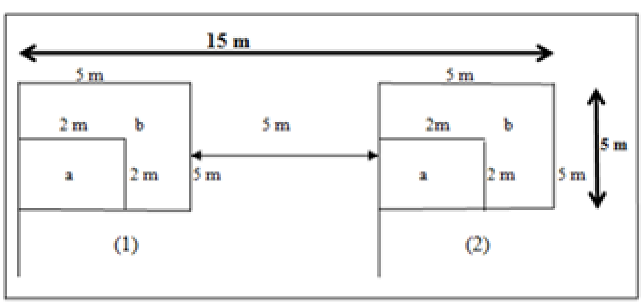

Fig. 1. Design of Plot and Transect for Vegetation Observation Area a: Plot for seedlings level, Area b: Plot for stake level, Transect 1: Accumulated plastic waste, Transect 2: Not accumulated plastic waste.

Plot size used for the stake (tree diameter <10 cm, height > 1.5 m) is 5 m x 5 m, and for seeding (plant height <1.5 m) and undergrowth (ground cover) is 2 m x 2 m. The stem diameter calculation is performed at approximately the height of the chest or 1.3 m above the soil surface. The parameters noted were the name of the plant species and the number of species found in the research plot.

2.2.2 Data Analysis

Part 1, Environmental parameters (soil pH, soil moisture, air temperature, and air humidity) measured at the waste disposal sites are geostatistically analyzed and mapped in ArcGIS 10.4 software. Empirical Bayesian kriging as a geostatistical interpolation used in the study is an interpolation method that accounts for the error in estimating the underlying semivariogram through repeated simulations (Krivoruchko, 2012).

Part 2, Density parameters of vegetation (seedling and stake level) for accumulated and not accumulated waste disposal sites are each calculated using the following formula (Soegianto, 1994).

$$\text{Absolute Density (AD)} = \frac{\text{(Number of Individual Counts per Species}}{\text{Area of Review}}$$
... Equation (1)

$$\text{Relative Density (RD)} = \frac{\text{(Density of Species A)}}{\text{Total Density}} \text{ x } 100\%$$
...Equation (2)

There are four waste disposal sites as samples in this study. These sites are compared to nearby not accumulated waste sites for statistical analysis as explained in Part 3. Part 3, t-test for two independent means of density parameters are generated to determine the difference in absolute density of seedling and stakes vegetation in accumulated and not accumulated plastic waste plots. Hypotheses for the t-test are H0: $\mu 1 = \mu 2$ (there is no difference in absolute density between accumulated and not accumulated plastic waste plots); H1: $\mu 1 \neq \mu 2$ (there is a difference of absolute density between accumulated and not accumulated plastic waste plots). Determination of the p and t values was calculated using Microsoft Excel (t-Test: Two-Sample Assuming Unequal Variances mean and standard deviation).

3. Results and Discussion

The environmental parameters measured at the waste location points namely air temperature, air humidity, soil moisture, and soil pH are shown in Figure 2. The air temperature predicted in ranges from 27.9 ^{0}C to 33 ^{0}C. According to Hatfield and Prueger (2015), the temperature range for plant growth is between 15 ^{0}C to 40 ^{0}C. Below or above this, the growth of the plant decreases drastically. Even though there are many plastic waste disposal sites, the air temperature in Kefamenanu is still considered to be the optimum air temperature suitable for plant growth. For instance, cool-season crops such as lettuce, many herbs, and salad greens have an optimum temperature range of approximately 16 ^{0}C to 22 ^{0}C. Warmer season crops such as tomatoes, capsicum, cucumbers have a higher range 18^{0}C to 28^{0}C. Air humidity is a very important environmental element that must be controlled for healthy plants. It is a measure of the amount of water vapour contain within the air. Air humidity controls the rate of transpiration and how the nutrients are received by plant. Air humidity at the northern part of Kefamenanu ranges from 32-40% and ranges between 41% and 53% at the southern part Kefamenanu. According to Mortensen (2000), the average value of daily or monthly humidity remains around 60%in the wet tropics, because the temperature variation in this area is small. Ideal humidity levels in a grow room range between 50% to 70% in vegetative growth, and 50% to 60% for flowering plants. Thus, air humidity in Kefamenanu predicted from waste disposal sites is considered to be not optimum and furthermore less suitable for plant growth as it is below 50%.

Soil moisture measured in the study is surface soil moisture which is the water contained in the upper 10 cm of soil. It appears that only a small area has low soil moisture (below 20%). It is observed that this area completely covered by plastic waste (no visible organic waste). According to Lakhsmi *et al.,* (2012) the average soil moisture for vegetated soil at a depth of 0-5 cm is 25%. Thus, soil moisture predicted from the plastic waste disposal sites in Kefamenanu is classified as suitable for plant growth because most areas have soil moisture above 20%.

Soil pH predicted for most areas in Kefamenanu is considered acidic ranging from 4.0 to 6.0. Only a small area has normal pH. According to Thomas (1996), nutrients in general will be easily absorbed by plants at pH 6-7, because at the pH most of the nutrients will easily dissolve in water. Soil pH conditions also determine the development of microorganisms in the soil. At pH 5.5 – 7, mushrooms and bacteria decomposers organic material will grow well. This pH also optimum for the microorganisms that are beneficial to plant roots. Thus, the soil pH of most areas in Kefamenanu is not optimum and suitable for plant growth.

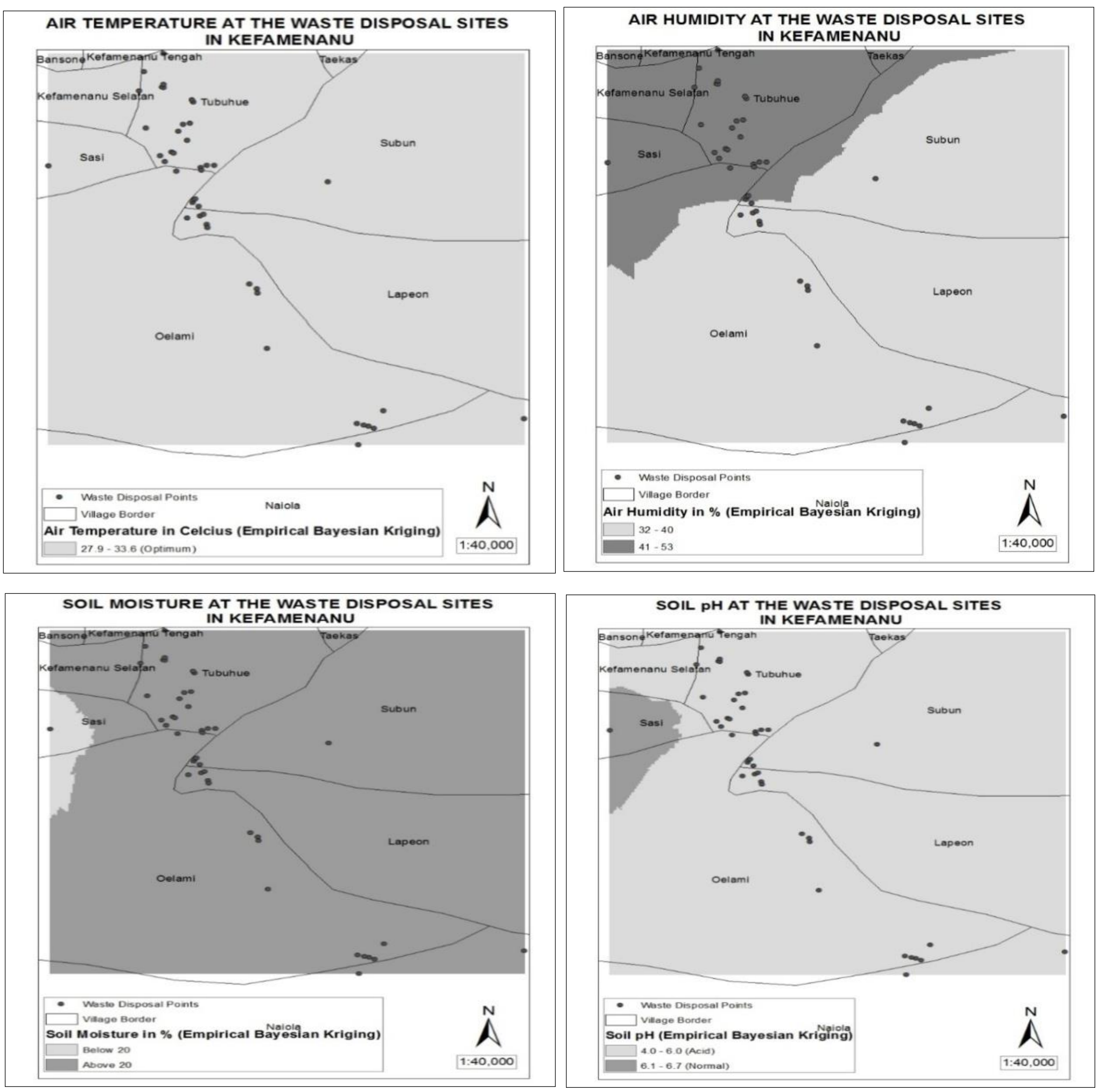

Fig. 2. Kriging Results of Environmental Parameters at the Waste Disposal Sites

Table 1. Density Parameters of Vegetation

Site	Point	Species: Indonesian Name	Species: Latin Name	NS	AD (%)	RD (%)
Seeding Level						
A	1	No Plant	-	0	0	0
	2	No Plant	-	0	0	0
	3	No Plant	-	0	0	0
	4	No Plant	-	0	0	0
B	1	1. Krinyu	1. *Charomolaenaodorata L.*	31	4.04	30.7
		2. Rumputteki	2. *Cyperusrotundus L.*	70		69.3
	2	Rumputmemerakan	*Themedearguens L.*	80	3.2	100.0
	3	1. Krinyu	1. *Charomolaenaodorata L.*	3	0.32	37.5
		2. Kayuputih	2. *elaleucaleucandendra*	5		62.5
	4	1. Krinyu	1. *Charomolaenaodorata L.*	37	5.08	29.1
		2. RumputCarulang	2. *leusineindrica L.*	90		70.9
Stake Level				**NS**	**AD (%)**	**RD**
A	1	1. Krinyu	1. *Charomolaenaodorata L*	1	0.08	50.0
		2. Gamal	2. *Gliricidiasepium*	1		50.0
	2	No Plant	-	0	0	0
	3	1. Krinyu	1. *Charomolaenaodorata L*	11	1.44	30.5
		2. Rumputgajah	2. *Imperatacylndrica*	25		69.4
	4	1. Krinyu	*Charomolaenaodorata L*	2	0.08	100.0
B	1	1. Krinyu	1. *Charomolaenaodorata L*	30	1.58	94.9
		2. Gamal	2. *Gliricidiasepium*	2		5.1
	2	1. Krinyu	1. *Charomolaenaodorata L*	81	3.56	91.0
		2. Kayuputih	2. *Melaleuca leucandendra*	3		3.4
		3. Jarakpagar	3. *Ricinuscommunis*	5		5.6
	3	1. Krinyu	1. *Charomolaenaodorata L*	3	0.16	75.0
		2. Kayuputih	2. *Melaleuca leucandendra*	1		25.0
	4	1. Krinyu	1. *Charomolaenaodorata L*	13	0.76	68.4
		2. Turis	2. *Cajanuscajan*	2		10.5
		3. Reo	3. *Canneacoromandelica*	3		15.8
		4. Pates	4. *Parkiaspeciosa*	1		5.3

A : Accumulated waste sites AD : Absolute Density NS : Number of Species
B : Not accumulated waste sites RD : Relative Density

The absolute density (AD) and the Relative Density (RD) of vegetation (seedling and stake level) in accumulated and not accumulated waste sites can be seen in Table 1.Table 2 shows that seeding plants are absence and hardly grow at acidic soil and lower air humidity, although the temperature and soil moisture are optimum. The similar pattern is found for stake plants where only a few grow in these four locations. For instance, at point 1, there are only 0.08 individuals living in every 1 m^2 of that waste disposal sites.

The independent t-test of absolute density for seeding level as shown at Table 3 shows that t stat <t table (-3.09 <3.18) which means the hypothesis is not significant that H0 is accepted and H1 is rejected. Different things are shown by the value of p where the value of P (T<=t) two-tail = 0.05 meaning significant hypothesis, H0 is accepted. This means that there is a significant difference in absolute density between the accumulated and non-accumulated waste sites. Although there is a significant difference in p-value, it is explained that the p-value cannot give information about the variables causing the difference in absolute density of vegetation (Figueiredo *et al.*, 2013). In this case researchers difficult to conclude that plastic waste is the cause of differences in absolute density between accumulated and not accumulated plastic waste sites.

The independent t-test of absolute density for stake level shows that t stat <t table (-1.36 <2.78) which means hypothesis is not significant that H0 is accepted and H1 is rejected. This means there is no significant difference in absolute density between the accumulated and non-accumulated areas of plastic waste. The value of P (T<=t) two tail> 0.05 (2.24 > 0.05), hence hypothesis is not significant.

Table 2. Environmental Parameters and Vegetation Density at Waste Disposal Sampling Site

Point	Air Temperatuire (°C)	Air Humidity (%)	Soil Moisture (%)	Soil pH	Absolute Density (Stake)	Absolute Density (Seeding)
1.	31.3	35	80	4.0	0.08	0
2.	31.9	35	80	4.0	0	0
3.	32.3	34	60	5.2	1.44	0
4.	30.7	44	40	6.2	0.08	0

According to statistical inferential analysis through t-test, it cannot be proved that there is a difference in vegetation density between accumulated waste sites and not accumulated plastic waste sites because the number of samples analyzed is small. The t-test result cannot yet show that the absence or lack of vegetation in the accumulated plastic waste sites are caused by the amount of garbage accumulated in that place. It is suggested to increase the number of t-test samples to achieve statistical proof. Statistical descriptive calculation by calculating the mean of absolute density as illustrated in Figure 3 represents that there is a difference in the mean of vegetation density (either absolute density or relative density) between accumulated and non-accumulated plastic waste sites.

Table 3. t-Test for Absolute Density of Vegetation

t-Test for Absolute Density: Two-Sample Assuming Unequal Variances		
	Seeding	Stake
t Stat	-3.09	-1.36
P(T<=t) one-tail	0.02	0.12
t Critical one-tail	2.35	2.13
P(T<=t) two-tail	0.05	0.24
t Critical two-tail	3.18	2.77

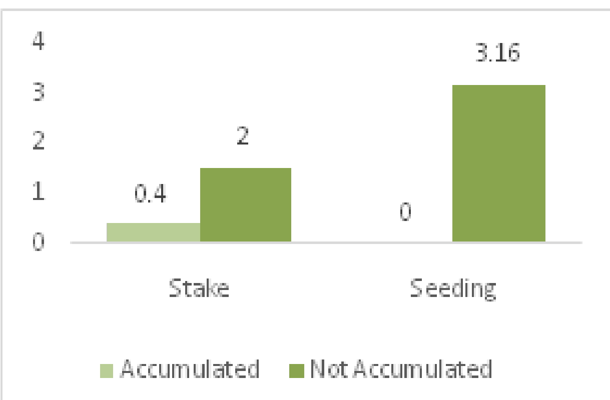

Fig. 3. Mean of Absolute Vegetation Density

4. Conclusion

In light of the study that has been undertaken and described herein, the following general conclusions have been identified. First, even though there are many plastic waste disposal sites, the air temperature in Kefamenanu is still considered to be the optimum air temperature suitable for plant growth. Air humidity in Kefamenanu predicted from waste disposal sites is considered to be not optimum and furthermore less suitable for plant growth as it is below 50%. Soil moisture predicted from the plastic waste disposal sites in Kefamenanu is classified as suitable for plant growth because most areas have soil moisture above 20 %. Soil pH predicted for most areas in Kefamenanu is considered acidic ranging from 4.0 to 6.0. Only a small area has a normal pH.

Second, according to statistical inferential analysis through t-test, it cannot be proved that there is a difference in vegetation density between accumulated waste sites and not accumulated plastic waste sites. Statistical descriptive calculation by calculating the mean of absolute density represents that there is a difference in the mean of vegetation between accumulated and non-accumulated plastic waste sites. It is suggested for the next researcher to increase the number of waste disposal sampling sites to attain statistical inferential result.

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Conflict of interest: Non declare