J. Basic. Appl. Sci. Res., 2(4)3174-3180, 2012
© 2012, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

The Difference of Vegetation Type Impact Due to Surface Run off and Erosion in the Upstream of Tondano Watershed, North Sulawesi Province

Dennie Heroike Rompas[1], Sugeng Prijono[2,*], Zetly E Tamod[3], Soemarno[2]

[1]State University of Manado, North Sulawesi
[2]University of Brawijaya, Malang, Jawa Timur
[3]University of Samratulangi, Manado, North Sulawesi

ABSTRACT

This study was intended to measure surface run off rate and actual erosion value of 5 types of selected vegetations (trees) in the upstream of Tondano Watershed. Selection of vegetations were based on the highest important value of index. The 5 types of vegetations were included: *E.celebica, E.aromaticum, T.cocao, G.Mangostana,* and *A.pinnata*. The methodology consisted of erosion measurement directly during rainy season (November 2010 to February 2011). To measure surface run off and volume of erosioned soil, it was built drum storage. Dimension of trial block was 2 x 22 m and it was restricted with sinc plated wall. Plot test used for measuring actual erosion and run off was 15 tests. Result showed that type of *E.celebica* had the lowest surface run off rate and erosion, but *E.aromaticum* had the highest surface run off rate and erosion.
KEY WORDS: surface run off, erosion, type of vegetation, Tondano Watershed.

INTRODUCTION

Many models of hydrology had been long developed to simulate and to help researchers for understanding hydrologic processes, including infiltration process, surface run off process, erosion, etc. Some hydrologic models of watersheds were often used as strategic tools for analysing the effect of land use changes [1]. Surface run off as one of hydrological aspect that influenced by land use change became an important aspect to be considered in the land management and development. It was important to accomodate the characteristic of watershed such as topography, soil structure, land use which very influenced surface run off process.

Degradation of watersheds could increase high erosion into the downstream of river. There was demanded an accuracy analysis of erosion. Indonesia was as a tropical region. It had dry and rainy season which was as repeated cycle. This repetition cycles wiould alter the physical capacity of soil became more vulnerable to erosion [2].

In the large scale, vegetation would give positive impact to ecosystem balance. The function of vegetation in ecosystem generally related to regulary the balance of carbon dioxide and oxygen in air, repair of physical, chemical, and biological soil, regulary ground water, etc. Variety of vegetation impact was due to type and composition of vegetation. For example, vegetation generally would decrease soil erosion rate and it was depend on type and composition of vegetation.

Different impact of vegetation type to water management system was caused by different architecture model of each vegetation type. Architecture model generally was applied for habitus vegetation which was as a morphology illustration at the time being a phase of tree growth series. Architecture model of certain vegetation influenced translocate rainfall into stem flow rate, water permeating petals, infiltration, and surface flow rate at an area related to vegetation function in decreasing erosion rate. The influence of vegetation type to erosion rate was different, so that conversion of vegetation type to the other form would cause changes in function of vegetation at this area. Hairiah *et.al.* [3] said that function exchange from forest to coffee plantation would decrease input of mulse and changed the condition of soil micro climate due to opened area [4].

***Corresponding Author**: Sugeng Prijono, University of Brawijaya, Malang, Jawa Timur.
Email: sugeng_prijono@yahoo.com

Based on the quantitative value of soil erosion at habitat which was growed by the different vegetation, it showed that the lowest erosion was found at ecosystem of natural forest. The value was 0.002-0.31 ton/ha/year or it was almost no erosion. But if there was forest cutting and land use change into agricultural area, erosion rate would sharply up to approximate 90-7,000 times for the area which was growed with turned along plantation system. Erosion rate would increase again if it was planted with mono-culture and it was more serious if the area was blank and the erosion rate would be up to approximate 56,000 times. This data showed that vegetation had very important function in regulating hydrological cycle of a ecosystem. In ecosystem of tropical rain forest, if there was high intensity of rainfall, the rain would be transformed through some steps so that kinetic energy of rainfall which could make soil damaged, would be decrease. Part of rain would be held in leaf and evaporated back to atmosphere and then the rest of rain was flowed through stem flow and throughfall. Therefore, water damaging power would be minimized by vegetation and then surface water would enter the soil through infiltration process so that would decrease surface run off.

Nowadays, in the hilly of Tondano Lake, land use exchange from natural forest to the area of plantation, agriculture, and real estate caused flood at rainy season, serious discharge decreasing at dry season, and decreasing area and shallowing Tondano Lake.

MATERIALS AND METHODS

Data of Minahasa Forestry Office (1994) showed that Tondano Lake had watershed number area of 32,052 ha and the catchment area was included Langowan, Tompaso, Kakas, Eris, Remboken, Tondano, and Tomohon. The upstream area number was 22,090 ha and the catchment area was included Airmadidi and Manado. Map of location was as in Figure 1.

This study was intended to evaluate and analysis erosion rate in Tondano sub-watershed. The steps of this research were collecting, classifying, and analysing of data. It was used empirical and actual approaches. Measurement of erosion directly was carried out at rainy season in November 2010 until February 2011. For measuring the volume of erosioned soil, there was built stoarge (drum) and located under the area of study. The dimension of trial space was fit to field condition and it was selected the largest space. Space border of soil hillock was built for blocking inflow or outflow from erosion space. Run off and erosion flowed through run off way after apron was receiving in drum. If there was more run off, it would be made divider in the storage. Surface run off received in second and third drum was only 1/5 part and the rest (14/15 part) was spilled out.,

Figure 1 Map of Location

There were 15 plot tests for measuring actual erosion and run off in this study. These plot tests were selected due to the variation of land uses, type of soil, type of vegetation, and influenced rainfall station. Each plot test needed 3 drums with diamatre of 56 cm and the height from base to divided hole was 70 cm. At first and second drum was made 15 holes and each hole had the same diametre of 3 cm and there was the same space among them. The third drum was not made hole. The first, second, and third drum was related with a pipe. The aim of this system was if the first drum was full of run off, the water could flow to second drum, etc. Over the drums was covered for holding rainfall could not enter in drum directly. Apron was made of rectangle zinc. The dimension was 30 cm x 30 cm x 20 cm. Each space was restricted with plat zinc wall with dimension of 22.5 x 5 m^2.

Recording of data was carried out at each frequent of rainfall. The data was included surface run off and erosion as follow:

a. Measuring of run off

Measuring of run off on each sample was carried out every day at the same time and minimal was for 30 times measuring. The formula of run off volume was as follow: [5]

$$V_{ap} = V_1 + 11\ V_2$$

Note:

V_{ap} = total volume of surface run off (l)
V_1 = volume of surface run off at first drum (l)
V_2 = volume of surface run off at second drum (l)

b. Measuring of soil erosion

Soil erosion was measured together with surface run off rate and used the same tool. Volume of soil erosion was determinied every day (in gram/m^3/day). Then field collected data was analysed using Biplot analysis. This method was developed to know the relation pattern among the variables (it was positive or negative) and the relative relation between variable and object of observation [6].

RESULTS AND DISCUSSION

Analysis result of surface run off on each vegetation in dry and rainy season was presented as in Table 1 below. It showed that surface run off in rainy season and dry season for each vegetation was relative homogeneous due to daily rainfall. The highest surface run off was found on *E. aromaticum*, its value was 9.15 liter and the lowest was on *E. celebica* with surface run off of 4.48 liter. In rainy season, the highest surface run off was found on *E. Aromaticum*, the value was 49.19 liter and the lowest was on *E. Celebica* with surface run off of 27.15 liter. In general surface run off rate in rainy season was higher than in dry season, because infiltration rate in dry season was higher than in rainy season. Therefore, soil saturation due to infiltration in rainy season was faster occured and there was some water was flowed as surface run off.

The value of surface run off was very important to the conservation effort of Tondano Lake because surface run off would take over erosioned soil and it could accelerate process of sedimentation and shallowing the whole Tondano Lake. Therefore, plantation of *E.aromaticum* in upstream of Tondano Watershed had to consider the pattern and plant spacing. Plantation with regular row would increase the probability occurance of surface run off because it was not held by vegetation. Plantation was carried out with the pattern of intermitten row so that the planted vegetation could be increased and the probability occurance of surface run off was minimized. Especially for the area which had planted with this kind of vegetation, it had to be made effort of conservation by planting the vegetation which showed the value of under surface run off canopy was low. Result showed that *E.celebica* was the best vegetation planted in space of *E.aromaticum* so that could minimize the danger of surface run off.

Table 1 the average of surface run off of each vegetation in upstream of Tondano Watershed in dry and rainy season.

No	Location	Scientific name	Surface run off (l)		
			Dry season	Rainy season	Average
1	Kayu wasian area	*E. celebica*	4,48	27,15	15.81
2	Clove area	*E. aromaticum*	9,15	49,19	29.17
3	Cocoa area	*T. cocao*	8,24	40,38	24.31
4	Mangosteen area	*G. mangostana*	6,39	41,66	24.02
5	Pinnata area	*A. pinnata*	5,49	36,54	21.01

Figure 1 showed the relation pattern between rainfall and surface run off in dry season was positive. It meaned that there was rainfall increasing in location of study and it was followed by surface run off rate in the sense of amount. For the type of *E.aromaticum*, rainfall increasing would impact serious increasing of surface run off rate and it was higher than the others. But *E.celebica* had the lowest value of surface run off and it was separated under the other curves. *G.mangostana* and *A.pinnata* were in the middle group. It meaned that the value of surface run off was moderate and it was between the highest and lowest values. The surface run off value of *T.cocoa* was closer to the highest value of surface run off.

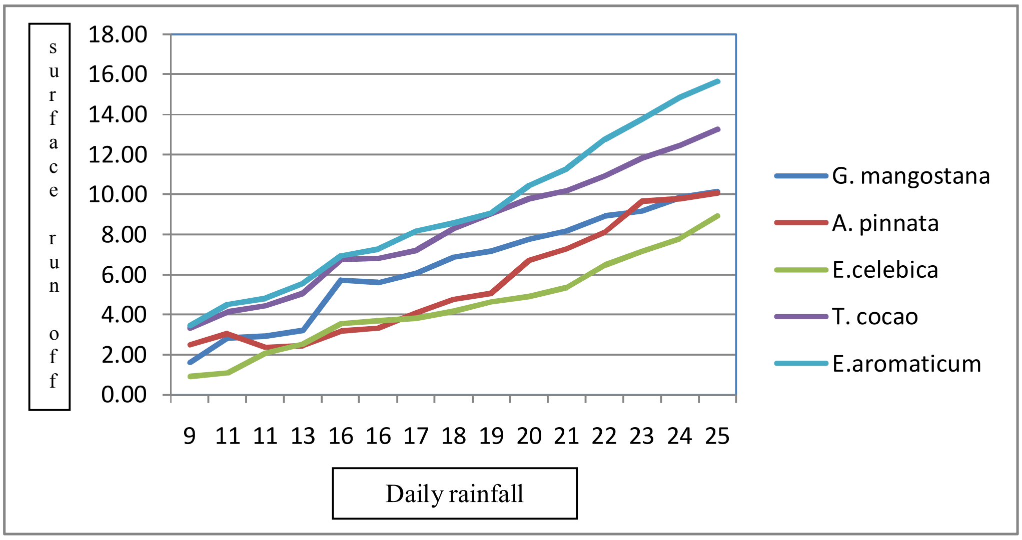

Figure 1 Inter related pattern of rainfall (mm) in dry and rainy season (mm)

In rainy season, rainfall increasing would impact to surface run off rate as serious increasing in average number. Figure 2 presented that *E.aromaticum* was a type which the highest surface run off among 5 obsreved vegetations. But *E.celebica* was a type which under surface run off canopy. The difference was caused by mulse production of 4 others type of vegetations was lower than this one. Beside it, the ability of each vegetation to hold water and infiltration value also influenced the value of under surface run off canopy of each observed vegetation.

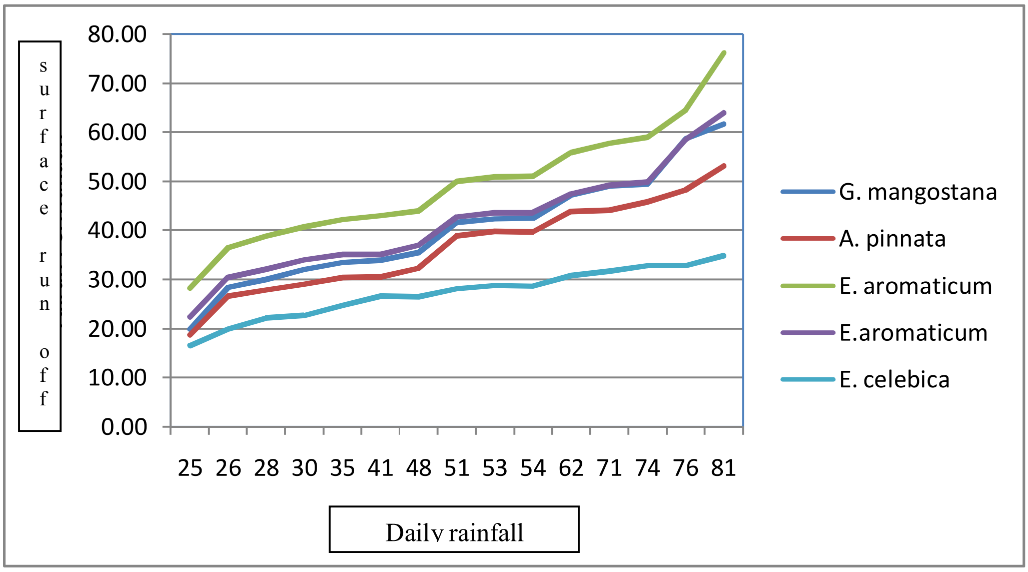

Figure 2 Relation pattern between rainfall in rainy season (mm) and surface run off (liter)

In general, relation pattern between rainfall and surface run off for each vegetation was almost the same where as there was different in volume of surface run off. Average rainfall increasing would be responsed and gave impact as surface run off rate increasing with the same pattern relatively on the curve. The difference sense of surface run off increasing was on the rainfall more than 50 mm and it was significant difference on the rainfall of 71 mm until 81 mm. It was different if compared with the curve on dry season, but in general, relation pattern between daily rainfall and surface run off rate for the whole type of vegetation was positive.

Result of erosion analysis in dry season and rainy season was described as in Table 2 below. It showed that erosion in rainy season as well as in dry season for each vegetation was different. The highest erosion was found on *E.aromaticum*, it was 0.64 gram/m^2/day and the lowest was on *E.celebica*, it was 0.18 gram/m^2/day.

In rainy season, the highest erosion was on the type of *E.aromaticum*, its erosion rate was 0.93 gram/m^2/day and the lowest was on the type of *E. celebica,* its erosion rate was 0,32 gram/m^2/day. In general, erosion value in rainy season was higher than in dry season, because surface run off in dry season caused erosion lower than in rainy season.

Table 2 the average of under soil erosion canopy for each vegetation in the upstream of Tondana Watershed

No	Location	Scientific name	Erosion (mg/m^2/day)		
			Dry season	Rainy season	Average
1	Kayu wasian area	*E. celebica*	0,18	0,32	0,25
2	Clove area	*E. aromaticum*	0,64	0,93	0,78
3	Cocoa area	*T. cocao*	0,53	0,74	0,63
4	Mangosteen area	*G. mangostana*	0,32	0,58	0,45
5	Pinnata area	*A. pinnata*	0,29	0,42	0,36

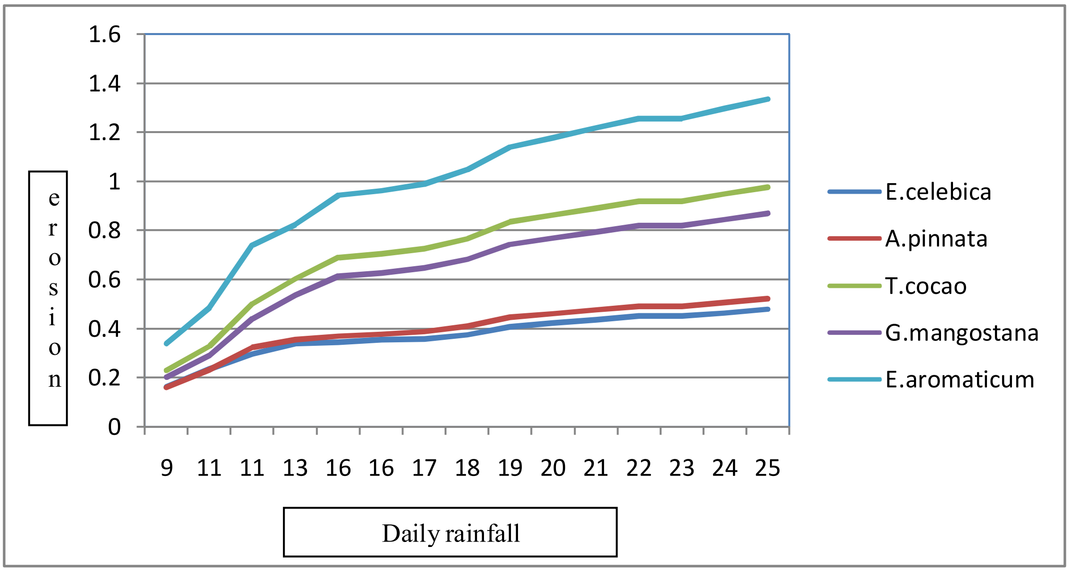

Figure 3 Relation pattern between rainfall in dry season and soil erosion

Figure 3 showed that the difference on relation pattern between rainfall and soil erosion was positive. It meaned that there was rainfall increasing and it would be followed with the erosion rate increasing in the sense of amount. In spite of rainfall was less than 13 mm; erosion value was still zero or there was no surface erosion because part of rainfall to forest was entering in soil through infiltration process. Variation of erosion was not only influenced by rainfall but it was influenced too by other environmental factor and each character of vegetation.

In rainy season, rainfall increasing would give any impact to erosion rate as the increasing of real average amount. Figure 4 showed that *E. aromaticum* had the highest erosion value among 5 types of abserved vegetations. The significant difference was caused by surface run off of the three types was lower than the stem diametre of other vegetation.

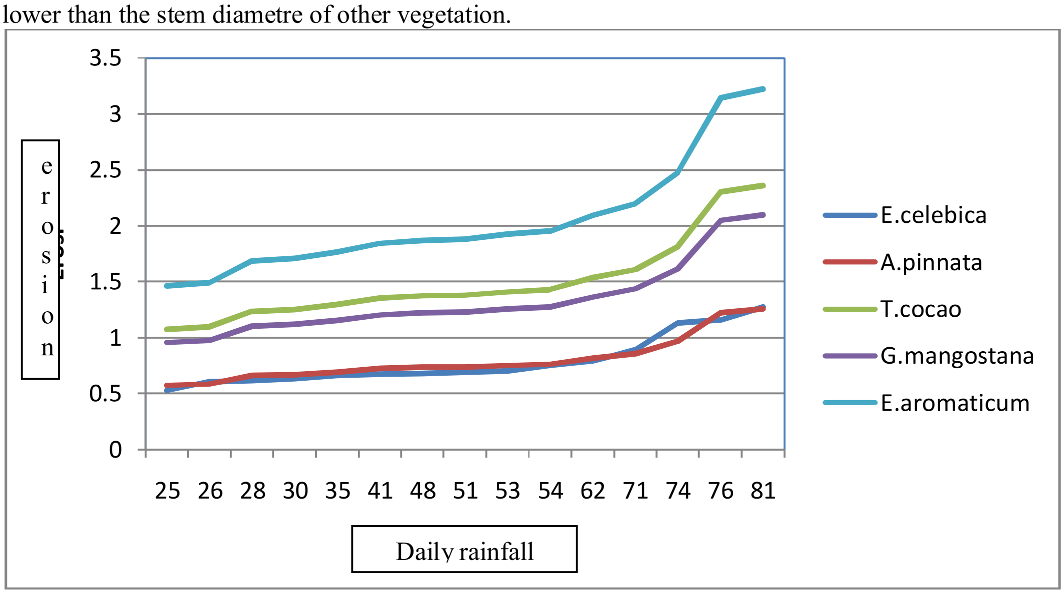

Figure 4 Relation pattern between rainfall in rainy season and soil erosion

In spite of the difference in the number of erosion for each vegetation, but in general, the relation pattern between rainfall and erosion rate for each vegetation was almost the same. The average of rainfall increasing would be responsed or give impact as increasing on erosion rate of soil surface.

CONCLUSION

Based on the analysis as above, it was cncluded that the best parametre of surface run off for the whole type of vegetations was found on *E.celebica*, because it had the lowest value (the average was 15.82 liter), but *E.aromaticum* was not so good because it had the highest value (the average was 29.17 liter). The best type due to erosion parametre was *E.celebica* because it had the lowest erosion value (the average was 0.25 g/m^2), but *E.aromaticum* was not so good because it had the highest erosion (the average was 0.79 g/m^2).

REFERENCES

1. Harisuseno, Donny. 2010. Application of GIS-Based Spatial Analysis on Developing Infiltration Zone Mapping in Glundeng Watershed, Brantas River Basin, East Java, Indonesia. *International Journal of Academic Research*, Vol 2(5): 206-209

2. Asmaranto, Runi; Soemitro, Ria Asih Aryani; and Anwar Nadjadji. 2010. Changes of Soil and Drying Cycle Repetitions on the Residual Soil. . *International Journal of Academic Research*, Vol 2(5): 149-152

3. Haeriah, K., H. Sulystiani; D., Suprayogo, Widianto, P. Purnomosidi, R.H. Widodo; and M. Van Noordwijk. 2006. Litter Layer Residence Time in Forest and Coffee Agroforestry Systems in Sumberjaya, West Lampung. *Forest Ecology and Management*, 224: 45-57.

4. Aini, F.K., F.X., Susilo, B. Yaniwiadi dan K. Hairiah, 2006. Meningkatnya potensi sebaran hama rayap *Odontotermes* spp setelah alih guna hutan menjadi agroforestri berbasis kopi; apakah perubahan iklim mikro lebih mempengaruhi perubahan populasi dari pada ketersediaan makanan? *Agrivita* (28) 3:221-227.

5. Santosa W. 1985. *Aliran Permukaan dan Erosi Pada Tanah Yang Tertututp Oleh Tanaman Teh dan Hutan Alam Gambung Bandung*, Program Pasca Sarjana, IPB.

6. Jollife IT. 1986. *Principal Component analysis*. Springler-Verlag. New York, 271.