Geological Society of Malaysia, Bulletin 46
May 2003; pp. 111–114

Soil erosion of a logged-over tropical forest, Pasoh, Negeri Sembilan

MOHD KAMIL YUSOFF, MUHAMMAD FIRUZ RAMLI, LAW JIUN TAU AND
WAN NOR AZMIN SULAIMAN

Department of Environmental Sciences, Universiti Putra Malaysia
43400 UPM Serdang, Selangor
Email: mkamil@fsas.upm.edu.my

Abstract: This study was conducted in the area of logged-over tropical forest in Pasoh Forest Reserve, Kuala Pilah, Negeri Sembilan. The attempt of this study was to investigate and observe soil erosion of a logged-over tropical forest. Soil erosion was monitored by using erosion pins at five unbounded research grids in a 100 m x 100 m research plot for 154 days. The occurrence of soil erosion and soil deposition were observed. Among the research grids, the maximum soil erosion was 14.6 mm and the maximum soil deposition was 7.2 mm. The forms of soil erosion that occurred were sheet erosion and splash erosion. Generally, the pattern of soil erosion varied significantly between one location and another within the plot. However, the pattern of erosion at one location did not change significantly with time.

Abstrak: Kajian ini dijalankan di kawasan hutan tropika yang pernah dibalak di Hutam Simpanan Pasoh, Kuala Pilah, Negeri Sembilan. Kajian ini bertujuan untuk mengkaji dan memerhati hakisan tanah di kawasan tersebut. Hakisan tanah diawasi dengan mengguna pin hakisan di lima lokasi grid bersaiz 100 m x 100 m untuk tempoh 154 hari. Hakisan dan pemendapan tanah telah diawasi. Di kalangan grid-grid kajian, hakisan tanah maksimum ialah 14.6 mm dan pemendapan tanah maksimum ialah 7.2 mm. Jenis hakisan tanah yang berlaku ialah hakisan kepingan dan hakisan percikan. Secara umumnya, bentuk hakisan tanah berbeza di antara suatu lokasi dengan lokasi-lokasi yang lain di dalam plot kajian. Namun begitu, bentuk hakisan tanah di sesuatu lokasi tidak berubah dengan nyata mengikut masa.

INTRODUCTION

Soil is defined as a dynamic natural body on the surface of the earth in which plant grow, and is composed of mineral and organic materials and living forms (Brady, 1974). Soil is basic to life and has been one of the major resources of great civilizations. The valley of soils of the Nile, of the Tigris and Euphrates rivers in Mesopotamia, and of the Indus, Yangtze and Hwang Ho rivers in India and China were the platforms for great civilizations of mankind. However, soil destruction and mismanagement brought the downfall of some of the civilizations.

Therefore, the degradation of soil will lead to destructive consequences. Soil degradation is defined as a decrease in soil quality as measured by changes in soil properties and processes, and the consequent decline in productivity in terms of production now and in the foreseeable future (Stocking, 1995). Water erosion, wind erosion, excess of salts, chemical degradation, physical degradation and biological degradation. According to the soil degradation assessment by Oldeman (1990), 748 million hectare of the areas on earth is exposed to moderate and excessive water erosion.

The consequences of soil degradation include the removal of topsoil slice, nutrient loss and worsening of infiltration capacity (Stocking, 1995). These on-site physical processes will then affect crop production and cause economic loss, especially to land users. On the other hand, off-site impacts, too, cause disruption to society. Sediments from water erosion have brought damage to canals, water storage, irrigation schemes, ports and hydroelectric power plants.

There are many factors leading to soil degradation, one of which is tropical forest degradation. Road construction and logging are the major causes of surface erosion (Udarbe, 1992). Soil compaction caused by heavy logging machines and the exposure of forest soil by forest clearing and logging affects the water retention capacity of forest soils. Soils of this type have a very low infiltrability, resulting in the increase of runoff. Infiltration capacity generally tended to be higher in a natural forest or old-man-made forest compared with young forest or bare land (Onodera, 1992).

The main aim of this research is to study the behaviour of soil erosion process of a degraded logged-over tropical lowland forest.

METHODOLOGY

The research site is located at Pasoh Forest Reserve, Kuala Pilah, Negeri Sembilan (Fig. 1). The area was logged in 1984. Most of the vegetation is dominated by pioneer species such as *Malastoma sp.*, *Macarangga sp.*, *Imperata cylindrica* and few young commercial and non-commercial tree species such as *Dryobalanops sp.*, *Dipterocarpus sp.*, *Shorea sp.* and *Annonaceae.*

A one-hectare (100 m x 100 m) research plot was divided into 100 grids, each covered a 100 m^2 (10 m x 10 m) area. Five 100 m^2 (10 m x 10 m) unbounded research grids were determined among the 100 grids by using simple-

Table 1. Characteristics of the research grids

Grid	Location	Average slope gradient (%)	Exposure	Canopy cover (%)	Distinctive features
P1	3°00.74N, 102°21.11E	12	North	50	A bed of dead leaves on the ground of open area
P2	3°00.74N, 102°21.11E	11	North	45	A bed of dead leaves on the ground of open area
P3	3°00.47N, 102°42.38E	16	North	95	Dense canopy cover with some young trees (<1m) but less undergrowth.
P4	3°00.47N, 102°42.38E	14	North	70	Moderate canopy cover with some young trees (<1m) but less undergrowth.
P5	3°00.47N, 102°42.38E	13	North	90	Dense canopy cover with some young trees (<1m), very little undergrowth.

random-sample method and by considering their accessibility. The location of each sampling grid was determined by using Global Positioning System (GPS). Within each research grid, sampling points for various field measurements and samplings were determined by using judgement-sample method.

Soil erosion of the research plot was monitored by using erosion pins. Readings were taken once every 14 days. This method is one of the reconnaissance methods for point measurements of change of soil surface level (Hudson, 1993). As field visits could only be conducted periodically, methods that might face the problem of overflow of collected runoff, i.e. volumetric methods, were also not suitable for this study. Field plots that require quick accessibility to the site at all times of day and night and in all weather conditions were also not suitable. Point measurement was used in this study because it was inexpensive and simple, and a large number of points could be sampled. However, individual measurements of change in level at a single point will vary widely.

The erosion pins were aluminum tubes with the length of 30.00 cm and the outer diameter of 0.50 cm. The pin was driven vertically into the soil to the depth of 20.00 cm while the other 10.00 cm-portion of the pin was exposed above the soil surface. This allowed the measurement of soil surface level change with reference to the top of the pin. Ten erosion pins were installed in each of the sampling grids. The points on which the pins were installed were determined by using judgment-sample method as other

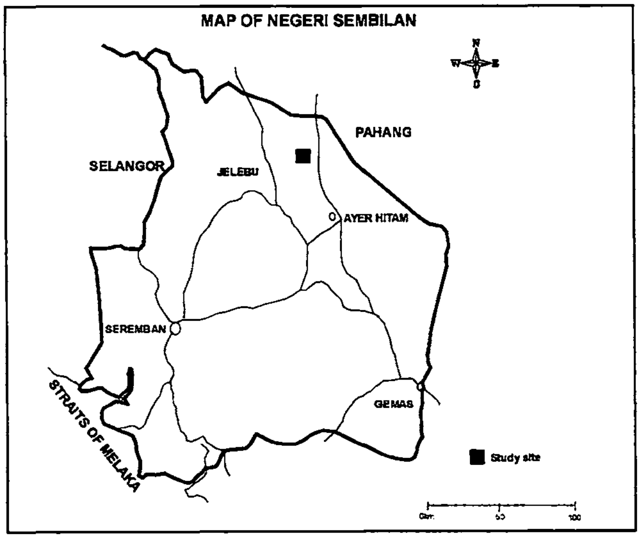

Figure 1. Study area.

sampling methods might locate the points at a location that was already occupied by forest plants. Periodical measurements were conducted once a fortnight. All of the measurements were taken at the part of the pins facing the east.

Amount of rainfall of the study site was recorded by an event recorder located at Kampung Lui Muda, which was located approximately 1 km from the research plot.

RESULTS AND DISCUSSION

The characteristics of the research grids that include average slope gradient, exposure, canopy cover and distinctive features are shown in Table 1.

Soil surface level changes that were recorded by erosion pins during the site visits are shown in Figure 2. The recorded readings were the changes in soil surface level for the period of the interval between the last measurement and the time when the readings were taken. The length of this measurement interval was approximately 14 days. The positive values indicate the occurrence of soil deposition while the negative values represent soil erosion.

Figure 2 shows the change in soil surface level of each grid for the whole study period. Figures 3 to 7 show the change in soil surface level of each grid recorded during each site visit. According to Figure 2, research grid P3 recorded the maximum soil erosion among the grids, 14.6 mm. Research grid P1 recorded the maximum soil deposition among the grids, 7.2 mm. The result shows that grid P1 and grid P5, which were located at the lower slopes of grid P2 and grid P3 respectively, experienced soil deposition while soil erosion occurred at grid P2 and grid P3. This suggests that more ground retreat occurred at higher parts of the slope while the sediment removed could have been transported to the lower parts of the slope.

Analysis of variance shows that the average ground retreat readings of the five grids have significant differences ($p < 0.05$). This indicates a single average ground retreat will not be representative for the five research grids. On the other hand, the analysis of variance also shows that erosion pins' readings did not vary significantly over time ($p > 0.05$).

No rill formation was observed. However, wet soil particles were sometimes found to be attached on the erosion pins. With the finding that there were no other major soil-particle-detachment and -transporting agents in the site except for some ants after detail observation, it can be concluded that the soil particles were moved to the surface

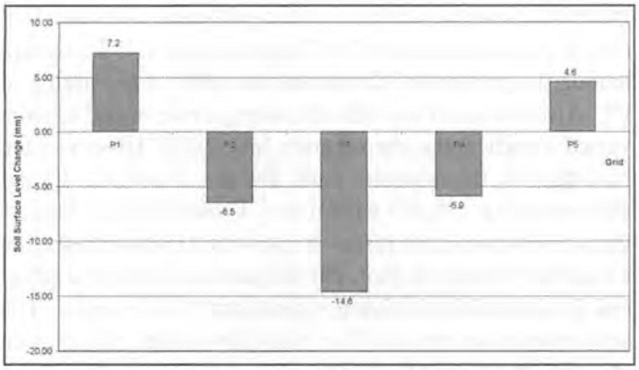

Figure 2. Soil surface level changes of the grids for the whole study period.

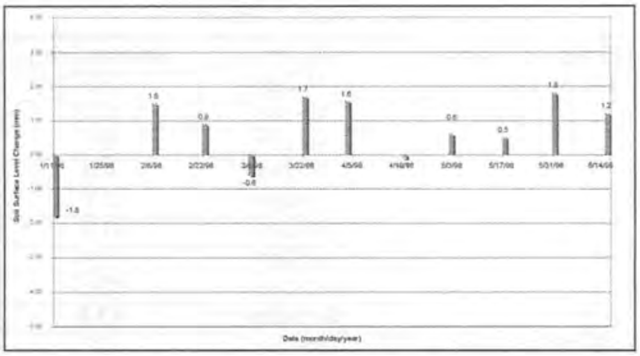

Figure 3. Soil surface level changes of research grid P1.

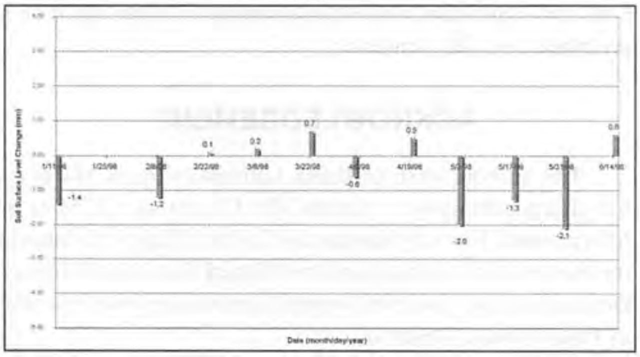

Figure 4. Soil surface level changes of research grid P2.

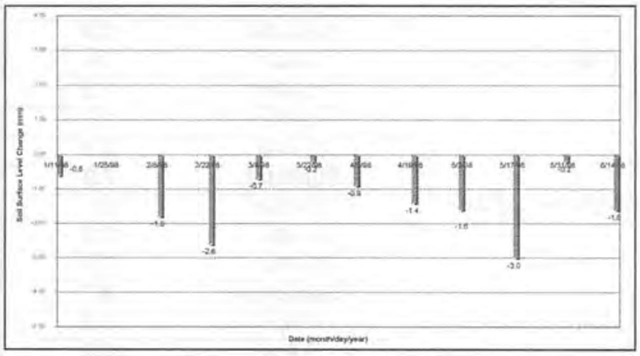

Figure 5. Soil surface level changes of research grid P3.

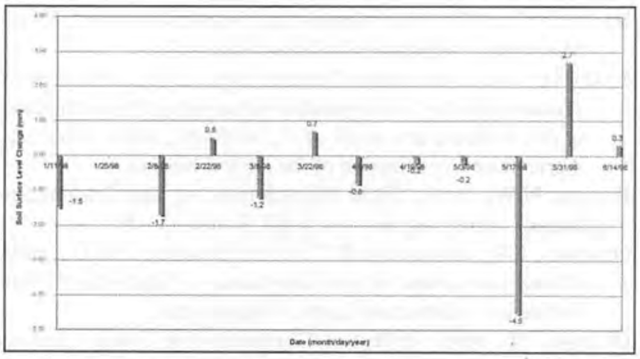

Figure 6. Soil surface level changes of research grid P4.

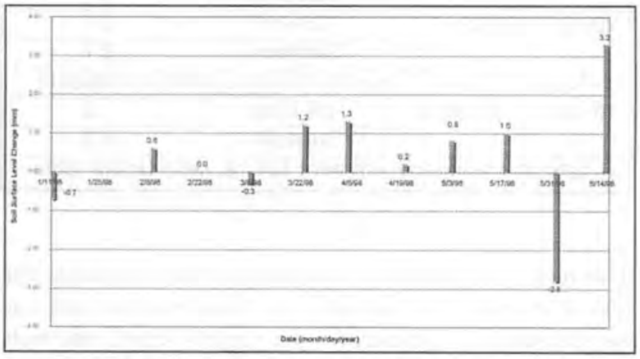

Figure 7. Soil surface level changes of research grid P5.

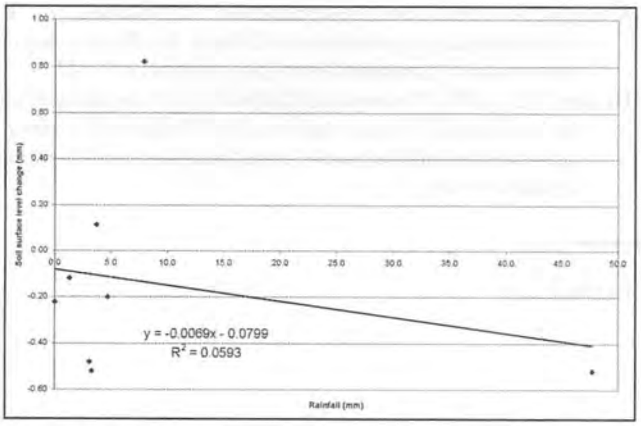

Figure 8. Interaction between rainfall and soil surface level change.

of the erosion pins by splash erosion. This suggests that sheet erosion and splash erosion were the erosion processes that occurred.

The rainfall amount recorded is shown in Table 2. The rainfall amount dropped drastically after January. However, continuous rainfall recorded was not available because of equipment failure.

Rainfall amount of the site and soil erosion of the grids are found to have a Pearson correlation coefficient of -0.244 with the R^2 of 0.059 as shown in Figure 8.

The negative correlation coefficient indicates that the increment in rainfall amount was able to cause soil erosion at the grids. However, the weak correlation suggests that the influence of rainfall amount was not so significant.

Table 2. Rainfall Records.

Sampling interval	Date	Rainfall (mm)
12-Jan to 25-Jan	14-Jan	3.8
	15-Jan	10.2
	16-Jan	6.6
	18-Jan	0.4
	19-Jan	0.1
	20-Jan	0.3
	22-Jan	5.9
	23-Jan	16.5
	Subtotal	**43.8**
26-Jan to 8-Feb	26-Jan	0.2
	30-Jan	3.7
	Subtotal	**3.9**
9-Feb to 22-Feb	/	0.0
	Subtotal	0.0
23-Feb to 7-Mar	7-Mar	3.3
	Subtotal	**3.3**
8-Mar to 22-Mar	8-Mar	1.4
	11-Mar	1.5
	13-Mar	1.5
	22-Mar	0.2
	Subtotal	**7.9**
23-Mar to 3-Apr	23-Mar	1.1
	27-Mar	2.3
	29-Mar	0.3
	Subtotal	**3.7**
4-Apr to 19-Apr	4-Apr	0.3
	5-Apr	0.4
	10-Apr	0.1
	11-Apr	3.9
	Subtotal	**4.7**
20-Apr to 2-May	23-Apr	3.1
	Subtotal	**3.1**
3-May to 17-May	Equipment failure, data unavailable	
18-May to 31-May	23-May	1.3
	Subtotal	**1.3**
1-June to 14-June	Equipment failure, data unavailable	

This might be caused by the location of the rain gauge that was at an open area located about 1 km from the plot, and not at the plot. Therefore, the records could not truly represent the actual amount, length and intensity of throughfall received by the grids while these factors could have imposed more significant influences to soil erosion at the plot.

CONCLUSION

Soil erosion and deposition were both observed at the research plot. For the research period of 154 days, the maximum soil erosion among the grids was 14.6 mm that occurred at research grid P3. The maximum soil deposition among the grids was 7.2 mm that occurred at research grid P1. Also observed was that the average rate of soil erosion varied significantly among grids ($p < 0.05$). However, the readings of the erosion pins did not show significant differences ($p < 0.05$) with time. These findings suggest that soil erosion of the research site varied from one location to another within the plot, but the pattern of soil erosion of one location did not change significantly over time. The soil erosion occurred at the plot falls within the erosion class of "high" (FAO, 1979).

The forms of soil erosion observed at the research site were sheet erosion and splash erosion. Nevertheless, if the trend that soil erosion pattern of one certain location did not vary significantly over time continues, there shall be a possibility of rill formation.

ACKNOWLEDGEMENT

The authors wish to thank Universiti Putra Malaysia for giving permission to attend the Conference, Center of International Forestry Research (CIFOR), Bogor, Indonesia for the research funding and the Negeri Sembilan Forestry Department for giving the permission to carry out research in Pasoh Forest Reserve.

REFERENCES

BRADY, N.C., 1974. *The Nature and Properties of Soil*, 8th ed. MacMillan Publishing Co., New York, 617.

FAO (FOOD AND AGRICULTURE ORGANIZATION), 1979. *A Provisional Methodology for Soil Degradation Assessment (with Mapping of North Africa at a scale of 1:5 million).* Rome: Food and Agriculture Organization of the United Nations.

HUDSON, N.W., 1993. Field Measurement of Soil Erosion and Runoff. *FAO Soil Bulletin*, FAO, Rome, 11-15.

OLDEMAN, L.R., HAKKELING, R.T.A. AND SOMBROEK, W.G., 1990. *Global assessment of soil degradation.* International Soil Reference Information Centre, Wageningen.

ONODERA, H., 1992. Effect of Degradation of Forest Land on Erosion and Infiltration Capacity of Soil. *Jircas International Symposium Series 1.* Japan International Research Centre for Agricultural Sciences, Tsukuba, 55-63.

STOCKING, M., 1995. Soil erosion and land degradation. *In:* T. O'riordan (Ed.), *Environmental Science for Environmental Management.* Longman Group Ltd., Harlow, 223-242.

UDARBE, M.P., 1992. The Impact of Tropical Forest Degradation on the Environment. *Jircas International Symposium Series 1.* Japan International Research Centre for Agricultural Sciences, Tsukuba, 21-26.

Manuscript received 3 March 2003