

**ASSESSMENT OF SOIL RE-DISTRIBUTION USING NUCLEAR
TECHNIQUES AND IT'S RELATIONSHIP WITH SOIL NUTRIENT
STATUS IN DIFFERENT LAND USES IN RANDENIGALA
RESERVOIR CATCHMENT OF SRI LANKA**

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ABSTRACT

Soil erosion in upper Mahaweli catchment causes reduction in reservoir capacity that affect adversely to the power generation and irrigation water supply to the Dry zone of Sri Lanka. Unavailability of sufficient information on soil erosion in different land uses hinders the effort of identification of erosion hot spots for prioritizing the implementation of soil conservation program with available limited resources. Therefore, soil redistribution (Erosion/Deposition) study was conducted in Heelpankandura sub catchment of Randenigala reservoir catchment in year 2014 using Fallout Radio Nnuclide (FRN) technique. Soil samples were collected in three parallel transects covering natural forest, plantation forest, home gardens and shifting cultivation vegetable land uses. Nine soil samples (45 cm depth) were collected from each land use. Two centimeter depth increment soil samples were collected up to 45 cm depth in reference site. Soil samples were analyzed for both radio-isotopes of ¹³⁷Cs and ²¹⁰Pb_{ex} activities using Gamma detector. Radioactivity values of soil samples were converted to soil erosion/deposition values using mass balance II model. Same soil samples were used to analyze soil nutrients and organic matter content. Natural forest recorded the 6.1 t/ha/yr net soil deposition and plantation forest, home gardens and shifting cultivation fields recorded 14.1 t/ha/yr 20 t/ha/yr, 50. 6 t/ha/yr net soil erosion values, respectively. Significantly highest soil available phosphorus, exchangeable potassium and organic matter content values were also recorded by the natural forest while shifting cultivation

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fields recorded the lowest. There was a significant negative correlation between soil erosion/deposition and soil organic matter content exists in natural forest, plantation forests, shifting cultivation and home garden land use systems. Based on the results, it can be concluded that soil erosion is negatively correlated with soil organic matter content in the studied location. Appropriate soil conservation measures are need to be implemented in plantation forests, home gardens and shifting cultivation fields to minimize soil erosion as the soil erosion in above land uses are higher than the tolerable limit of $11\text{t ha}^{-1}\text{yr}^{-1}$ for tropical countries .

Key words: Land uses, Nutrient contents, Nuclear techniques, Organic matter Soil erosion/deposition

INTRODUCTION

One of the most erosion prone region in Sri Lanka, the Upper Mahaweli Catchment (UMC), located totally within the Conservation area gazetted under the Soil Conservation Act No 25, produces considerable amount of tea, rubber, spices, vegetables and potato contributing around 20 % to the national GDP (Wickramasinghe, 1990). Several multipurpose reservoirs have been built in the Upper Mahaweli Catchment to generate hydropower contributing nearly 40-50 % of the total hydropower production in the country and providing irrigation water to the Dry Zone of Sri Lanka. Among the Mahaweli reservoirs, the Randenigala reservoir is the one with largest storage capacity of the entire system, possessing a gross storage of 860 million cubic meters. However, irrational land use practices in upper catchment areas cause extensive soil erosion resulting in loss of fertile soil and siltation of the reservoir (Hewawasam, 2010). At present, vegetables are grown extensively on steep slopes of the Randenigala reservoir catchment without proper land management practices. Consequently, this agriculturally active land is exposed to severe soil erosion and landslides, in parallel with a rapid rate of deforestation. Estimates of the rate of soil loss on hill slopes and sediment yields in the fluvial system indicate that the human-mediated activities in the Randenigala reservoir catchment have increased the rates of ongoing erosion over the background rates of natural erosion (Hewawasam, 2010). Thus, the river Mahaweli and its tributaries carry enormous amounts of sediments during the rainy seasons, both as bed load and suspended solids and are deposited in the Randenigala reservoir leading to a reduction

of storage capacity. Siltation in Randenigala hydropower reservoir could pose a serious threat to the reduction of hydropower generation capacity in the country and a more alarming situation could be anticipated in future. Therefore, proper implementations of the soil conservation act through effective conservation measures need to be ensured for sustainable land management in upper Mahaweli catchment. However, one of the major limitations for successful implementation of soil conservation act is the unavailability of sufficient soil erosion/sedimentation data under different land uses in catchment scale to plan and establish different soil conservation measures and to rehabilitate degraded lands.

Soil erosion can be estimated by number of methodologies such as erosion plots, erosion pins and sediment yields. However, all these methods have site specific constraints apart from being labour intensive (Peart *et al.*, 2006). Conventional methods used to measure soil erosion are time consuming and results obtained for an experimental plot are usually incomparable with one another. The use of FRNs such as ^{137}Cs and ^{210}Pb to measure soil erosion overcomes many of the limitations of conventional methods. These methods are a valuable alternative to conventional methods. In addition, FRN measurements can be used as a basis for studying both the spatial variability of soil loss and its magnitude. Use of ^{210}Pb as sediment tracer, has primarily focused on excess ^{210}Pb . This radio-nuclide differs from ^{137}Cs in two important ways. Firstly, it is of natural origin, and, secondly, its fallout input can be treated as essentially constant over time. Lead-210 (^{210}Pb) is a naturally occurring product of the ^{238}U decay series with a half-life of 22.2 years, that is derived from the decay of gaseous ^{222}Rn , the daughter of ^{226}Ra . Radium-226 exists naturally in soils and rocks and the ^{210}Pb in soils is generated *in situ* by the decay of ^{226}Ra and termed as supported ^{210}Pb and is in equilibrium with ^{226}Ra . However, upward diffusion of a small portion of the ^{222}Rn produced in soil and rock introduces ^{210}Pb into the atmosphere and its subsequent fallout provides an input of this radionuclide to surface soils and sediments that will not be in equilibrium with its parent ^{226}Ra . The amount of unsupported ^{210}Pb in a sample can be calculated by measuring both the ^{210}Pb and ^{226}Ra activities and subtracting the ^{226}Ra -supported ^{210}Pb component from the total ^{210}Pb in the sample.

Therefore, this study was conducted with the objectives of determining the soil erosion/deposition rates in different land uses using nuclear techniques and investigating

VU = vegetable upper, VM = vegetable middle, VL = Vegetable lower

HU = Home garden upper, HM = Home garden middle, HL = Home garden lower

PFU = Plantation forest upper, PFM = Plantation forest middle, PFL = Plantation forest lower

NFU = Natural forest upper, NFM = Natural forest middle, NFL = Natural forest lower

Reference = Reference site

Compilation of background information

The compiling of background information such as land use history, current agricultural practices, cultivation depth (plough depth) and annual rainfall was achieved by using the government reports of the Divisional Secretariats, Agrarian Service Centers and Natural Resources Management Centre of the Department of Agriculture. The specific land use/management practices used in the area was assessed through discussions with land owners.

Selection of reference site

For the comparison of fallout radionuclide inventory, reference area has been chosen from the uncultivated flat site of the hill top which had not been subjected to soil erosion or deposition. The vegetation type of the reference site is grassland. As the reference site is located in flat area of the hill top it is assumed that the area was not subjected to soil erosion and sediment deposition.

Sampling strategy in study area

Samples were collected in four major land uses in three parallel transects from upper, middle and lower position in the landscape. Land uses were selected avoiding the runoff water flowing from one land uses to other land use for accurate measurement of soil erosion in each land use. Table 1 shows the number of samples collected and processed for Fallout Radio-nuclides (FRN) analysis.

Table 1. Number of samples collected and processed for FRN analysis

Land use	No. of Samples collected and processed for FRN analysis
Home garden with perennials	09
Vegetable (shifting cultivation)	09
Plantation Forest	09
Natural Forest	09

Sampling strategy in reference site for determining fallout radionuclide (FRN) inventory

Samples were taken by sectional cores in 2 cm intervals up to 40 cm to determine the appropriate depth of penetration of ^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$ at reference site. In order to define the spatial variability of soil ^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$ inventory, bulk soil cores were collected from four parallel transects. Twelve cores were collected to a constant depth of 40 cm. Each transect consisted of 03 sampling points with the spacing of 10 m. At each sampling point, three cores were collected within an area of 1 m². Three replicated samples were mixed and one composite sample was made from each sampling point. The diameter of the core is 8 cm. In this study, presence of two radio-isotopes (^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$) were used or determined to increase the precision of the soil erosion/deposition data.

Sample preparation and analysis

Soil samples were air dried, disaggregated and passed through 2 mm mesh to separate the gravel. A sub sample from the weighed fine fraction were filled into a specific container designed for the detector and kept for 21 days to allow complete ^{222}Rn decay in order to achieve secular equilibrium for the measurement of ^{210}Pb and ^{226}Ra using its daughters of ^{214}Pb or ^{214}Bi . The activity of ^{137}Cs and ^{210}Pb were measured using a Hyper Pure Germanium (HPGe) detector installed at the Life Sciences Division of the Sri Lanka Atomic Energy Board with the relative efficiency of 30 % and the resolution of 2.20 KeV at the gamma energy of 1332.5 KeV of ^{60}Co . Each sample was counted for 20 hrs. The background of the system was measured using an empty container.

The ISOCS/LabSOCS software calibration method (Geometry Composer Method) was used for efficiency calibration. The reference materials, IAEA Soil - 6 and MBSS 2 of known ^{137}Cs content were used for method validation. The net area under peak at 661.5 KeV was used to determine the ^{137}Cs concentration of soil and for total ^{210}Pb is 46.5 KeV in Bq kg⁻¹. The $^{210}\text{Pb}_{\text{ex}}$ activity was determined by subtracting $^{210}\text{Pb}_{\text{supp}}$ (average of ^{214}Pb and ^{214}Bi activities) from total ^{210}Pb for each depth interval and core samples. The spectra were analyzed using the software packages Genie 2000. The minimum detection activity of ^{137}Cs is 1.0 Bq /kg for the counting time and the geometry used. $^{210}\text{Pb}_{\text{ex}}$ activity (Bq/kg) values assessed through the gamma detector were converted to Soil redistribution rates (t/ha/yr) using mass balance II model.

Soil nutrient analysis

The organic matter percentage of the soil was estimated by the rapid titration procedure given by Walkley and Black (1934). Available phosphorus of the soil samples were extracted with Olsen's extractant (0.5 M NaHCO₃) (Olsen *et al.*, 1954). Phosphorus in the extractant was estimated colorimetrically by ascorbic acid method (Murphy and Riley, 1962). Exchangeable potassium of soil samples were extracted by neutral ammonium acetate solution and were determined by using flame photometer (Jackson, 1979).

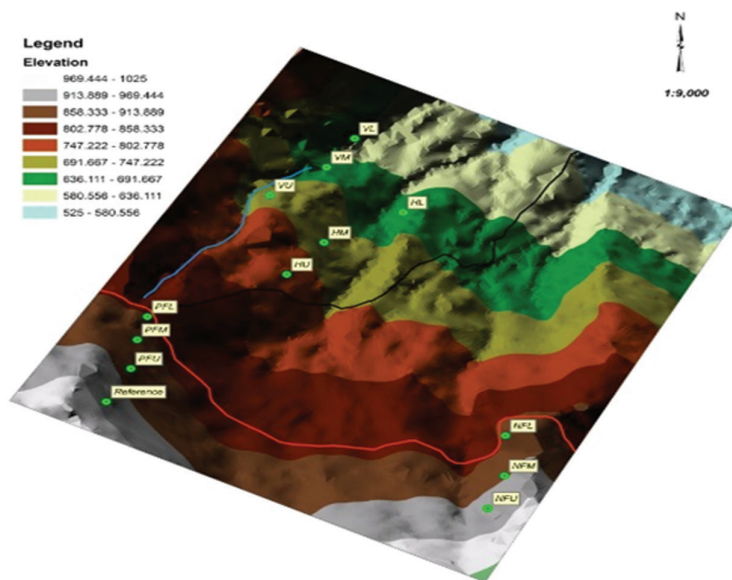
Statistical analysis

Statistical analysis of data was performed using the OPSTAT statistical package of Haryana Agricultural University, available online at www.opstat.com.

RESULTS AND DISCUSSION

The mean annual rainfall in the area is between 1,750 and 2,500 mm. About 80 % of the annual rainfall is received from September to January in the wet (*Maha*) season and the remaining 20 % in the dry (*Yala*) season from March to July. The elevation of the study area ranged from 525 m MSL to 1,025 m MSL (Figure 3). The ²¹⁰Pb_{ex} was mainly distributed up to 5 cm of soil depth (Figure 4). However, detectable amount of ¹³⁷Cs was not observed in sampling locations may be due to high erosion rates. As fallout of ¹³⁷Cs was not generally reported worldwide accumulated ¹³⁷Cs might not have available in study location in detectable quantities. Therefore, soil redistribution rates were presented using ²¹⁰Pb_{ex}.

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Figure 3. Elevation map of the Heelpankandura sub-catchment

All the sampling points of natural forests and plantation forests were located 802 m above sea level (Figure 3). However, home gardens were located 636 m to 802 m above mean sea level. Shifting cultivation fields were located 580 m to 747 m above mean sea level.

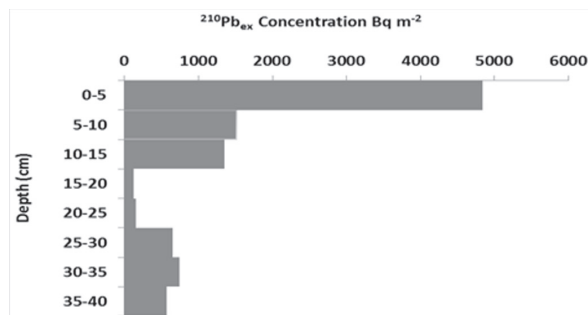


Figure 4. Vertical distribution of ²¹⁰Pb_{ex} at the reference site

Figure 4. explains the vertical distribution of $^{210}\text{Pb}_{\text{ex}}$ in 5 cm increment in the soil profile of the reference site. The concentration of $^{210}\text{Pb}_{\text{ex}}$ in the soil profile is determined by the natural decay of $^{210}\text{Pb}_{\text{ex}}$, the variation of fall out amount at a particular time period and the soil erosion and deposition. As it is assumed that the soil erosion and deposition is insignificant in reference site due to the flat terrain in hill top, natural decay of $^{210}\text{Pb}_{\text{ex}}$ and fall out amount at a particular time period can be considered as the governing factors of the differences of $^{210}\text{Pb}_{\text{ex}}$ concentration of soil profile. Normally, $^{210}\text{Pb}_{\text{ex}}$ concentration decreases with the depth of soil profile due to natural decay of $^{210}\text{Pb}_{\text{ex}}$. Extreme reduction of concentration from 15 to 25 cm depth of soil profile may be due to the low deposition of atmospheric $^{210}\text{Pb}_{\text{ex}}$. However, these variations does not affect to the estimation of soil erosion and deposition because same phenomena is happening to the surrounded area of the reference site. In computation of soil erosion and deposition, fallout radionuclide technique compares the concentration of $^{210}\text{Pb}_{\text{ex}}$ in reference site and other sampling areas of watershed; the variation of concentration in reference site does not have any effect on soil erosion/deposition estimation.

Table 2. Soil redistribution rate, Available phosphorus, Exchangeable potassium and percent organic matter in different land uses in Heelpankandura sub-catchment of Randenigala reservoir catchment.

Treatment (Land use)	Soil erosion/deposition (t/ha/yr)	Olsen P (ppm)	Exch. K (ppm)	Organic matter %
Natural Forest	+ 6.11 ^a	9.55 ^a	173.94 ^a	4.32 ^a
Plantation Forest	- 14.12 ^b	2.34 ^c	67.81 ^c	2.34 ^c
Home Gardens	- 19.98 ^b	4.38 ^b	114.97 ^b	3.28 ^b
Shifting cultivation	- 50.58 ^c	1.35 ^c	40.35 ^d	1.60 ^d
S.Ed.±	6.24	0.829	11.303	0.32
CD (p = 0.05)	18.57	1.721	23.466	0.67
CV %	44.32	39.89	24.15	23.77

Means followed by the same letter are not significantly different at 5% probability level. – Sign denotes net soil erosion and + sign denotes net soil deposition. S. Ed.± = standard error, CD = critical difference

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Table 3. $^{210}\text{Pb}_{\text{ex}}$ inventories and soil redistribution rates obtained from 9 bulk cores collected from the shifting vegetable cultivation in Heelpankandura sub catchment in Sri Lanka

Sampling point	$^{210}\text{Pb}_{\text{ex}}$ activity Bq kg ⁻¹	$^{210}\text{Pb}_{\text{ex}}$ activity Bq m ²	Soil redistribution rates t ⁻¹ ha ⁻¹ yr ⁻¹
VU-1	5.51	1471	-20.31
VU-2	4.63	1568	-18.52
VU-3	3.85	1405	-21.59
VM-1	3.65	1054	-29.72
VM-2	1.5	570	-47.5
VM-3	0.87	301	-66.42
VL-1	8	2151	-9.76
VL-2	0.2	76	-109.15
VL-3	0.1	37	-132.27

V = vegetable, *U* = upper, *M* = middle, *L* = lower. – Sign denotes net soil erosion and + sign denotes net soil deposition

Among the different land uses, significantly highest soil erosion of 50.6 t/ha/yr was recorded in shifting vegetable cultivation fields (Table 2). Generally, farmers clear the lands before the onset of seasonal rainfall. The area receives high intensity rainfall during the short rainy season. Land preparation with the onset of rainy season exposes the soil and disturbed the soil. When farmers cultivate vegetables in these steep slope lands (50% slopes) without appropriate soil conservation measures, the erosion rate of the area increases. Among the sampling positions the lowermost positions of the shifting cultivation fields recorded the highest soil erosion and upper position recorded the lowest amount (Table 3.). Use of conventional tillage practices, especially those used to produce fine seed beds produce an abundant source of small, lighter, particles that are vulnerable to erosive forces. Re-deposition of these fine particles on the soil surface can result in surface sealing and capping, which can reduce the infiltration capacity of a soil and increase the risk of surface runoff. Bandarathilake, (1999) also reported that majority of vegetable cultivated lands in upper Mahaweli watershed have annual erosion rates over 75 t/ha, thus significantly increasing the sediment yield in runoff and stream water. Dissanayake *et al.*, (2006) also reported that 52 t/ha/yr of soil erosion in marginal lands, 22 t/ha/yr of soil erosion in homestead and 10 t/ha/yr of soil erosion in plantation forests

in Uma oya catchment which is located adjacent to the Randenigala reservoir catchment. Therefore, there is a good consistency of soil erosion assessment data can be observed with nuclear technique although the technique is relatively new to Sri Lanka. Land slope also plays an important role in soil erosion rate in sloping lands as previous study using erosion plots in 30 % slope land in the same catchment recorded soil loss of 20 t/ha in brinjal cultivated fields (Chandrapala *et al.*, 2016). Compared to the other land uses, shifting vegetable cultivation fields were located in the lowermost position of the catena. Therefore, runoff water receiving from other land uses also might have caused to the high soil erosion rates under shifting cultivation.

Table 4. $^{210}\text{Pb}_{\text{ex}}$ inventories and soil redistribution rates obtained from 9 bulk cores collected from the home gardens in Heelpankandura sub catchment in Sri Lanka

Sampling point	$^{210}\text{Pb}_{\text{ex}}$ activity Bq kg^{-1}	$^{210}\text{Pb}_{\text{ex}}$ activity Bq m^2	Soil redistribution rates $\text{t}^{-1}\text{ha}^{-1}\text{yr}^{-1}$
HU-1	7	1718	-15.97
HU-2	11	3051	-0.24
HU-3	4	942	-32.92
HM-1	7	2091	-10.53
HM-2	4	875	-35.04
HM-3	13	4747	23.05
HL-1	11	3975	12.4
HL-2	2	556	-48.19
HL-3	1	247	-72.44

H = home garden, U = upper, M = middle, L = lower. – Sign denotes net soil erosion and + sign denotes net soil deposition

Home gardens (20 t/ha/yr) and plantation forest (14.1 t/ha/yr) recorded similar soil erosion rates (Table. 2). Three distinct canopy layers (Emergent, canopy and understory) could be observed in the home gardens in the studied area. However, the home gardens in the catchment are less diverse than natural forests. Out of nine sampling points, seven points recorded net soil erosion and two points recorded net deposition (Table 4). Deposition points were located in the lower and middle part of the home garden landscape.

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Table 5. $^{210}\text{Pb}_{\text{ex}}$ inventories and soil redistribution rates obtained from 9 bulk cores collected from the plantation forest in Heelpankandura sub catchment in Sri Lanka

Sampling point	$^{210}\text{Pb}_{\text{ex}}$ activity Bq kg ⁻¹	$^{210}\text{Pb}_{\text{ex}}$ activity Bq m ²	Soil redistribution rates t ⁻¹ ha ⁻¹ yr ⁻¹
PFU-1	0.1	27	-142.19
PFU-2	9	3306	10.38
PFU-3	18	4410	60.58
PFM-1	4	987	-31.59
PFM-2	8	2320	-7.68
PFM-3	3	697	-41.63
PFL-1	16.7	4255	31
PFL-2	7	1422	-21.26
PFL-3	10	3713	15.27

PF = Plantation forest, U = upper, M = middle, L = lower. – Sign denotes net soil erosion and + sign denotes net soil deposition

Plantation forest consisted mono-crop of Pinus (*Pinus caribea*). Under Pinus forest only one canopy layer could be observed and little undergrowth could be seen. Therefore, it might have recorded the higher erosion rate than natural forests. Out of nine sampling points five sampling points recorded net soil erosion in plantation forest (Table 5).

Table 6. $^{210}\text{Pb}_{\text{ex}}$ inventories and soil redistribution rates obtained from 9 bulk cores collected from the natural forest in Heelpankandura sub catchment in Sri Lanka

Sampling point	$^{210}\text{Pb}_{\text{ex}}$ activity Bq kg ⁻¹	$^{210}\text{Pb}_{\text{ex}}$ activity Bq m ²	Soil redistribution rates t ⁻¹ ha ⁻¹ yr ⁻¹
NFU-1	34	13461	38.39
NFU-2	14	3783	2.61
NFU-3	12	5197	7.83
NFM-1	12	3677	2.22
NFM-2	30	6211	11.58
NFM-3	7	2627	-1.49
NFL-1	10	2976	-0.33
NFL-2	17	3830	2.42
NFL-3	4	867	-8.23

NF = natural forest, U = upper, M = middle, L = lower. – Sign denotes net soil erosion and + sign denotes net soil deposition

Natural forests recorded 6.11 t/ha/yr net soil deposition. Since natural forest was located in the upper middle part of the catena, eroded soils from upper part of the landscape (degraded rocky shrub land) might have got deposited in the natural forest. However, the upper part of the forest landscape recorded slight soil erosion (2 t/ha/yr) but middle (16 t/ha/yr) and lower (4 t/ha/yr) parts recorded net deposition (Table 6.). The natural forest in the area is a multi-storied forest conserved by the Department of forests, Sri Lanka. Multi-storied canopy layer might have reduced the velocity of raindrops and thick ground litter layer might have reduced the velocity of runoff water minimizing the soil erosion (Table 2).

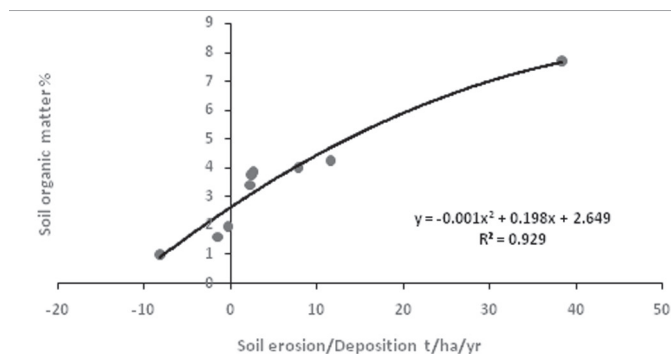
In general, all the land uses studied except natural forest recorded higher soil erosion rates than the tolerable limit of 11 t/ha/yr for tropical countries (El-Swaify *et al.*, 1982). Therefore, there is a need for implementation of soil conservation measures in these land uses.

Soil nutrient status

Among the different land uses studied, natural forest recorded the significantly highest soil available phosphorus, exchangeable potassium and organic matter percentage compared to other land uses (Table 2). Net soil deposition in the particular land use might have enriched the top soil with soil nutrients and organic matter. Well-structured canopy cover of natural forest might have provided large amount of organic matter as litter fall. Solar radiation intercepted by different canopy layers might have reduced the forest floor temperature reducing the microbial activity resulting slower decomposition of organic matter and loss of soil nutrients. Moorhead *et al.*, (1999) also reported that the rate of decomposition is influenced by many factors, because decomposition is a biological process carried out by bacteria and fungi, its speed will be affected by temperature and soil moisture. Among the land uses studied, shifting vegetable cultivation fields recorded the lowest soil available phosphorus, exchangeable potassium and organic matter content. Even though, it is reported the application of higher dose of chemical fertilizer to the vegetables (Rajakaruna, *et al.*, 2005), reconnaissance survey carried out under this study revealed that most of the shifting cultivated farmers apply a little dose of chemical fertilizer which also might have washed off due to heavy rainfall in uncovered lands without proper soil conservation measures. However, the result of nutrient status

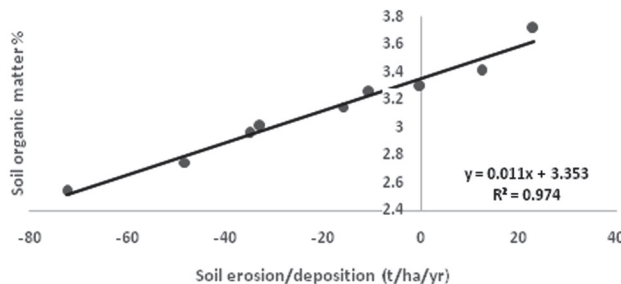
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in different land uses in present study is contradictory to the results of the study of Amarasekara *et al.*, (2008) where it was found that higher soil available phosphorus and exchangeable potassium content in vegetable cultivated fields than natural forest, plantation forest and home gardens. This disparity may be due to the differences in time of sampling. In the present study soil sampling was carried out at the fallow phase of shifting cultivation. However, during the cropping phase soil nutrient status may be different due to the application of fertilizer.



– Sign denotes net soil erosion and + sign denotes net soil deposition

Figure 4. Relationship between soil organic matter percent with rate of soil erosion/deposition in Natural forests

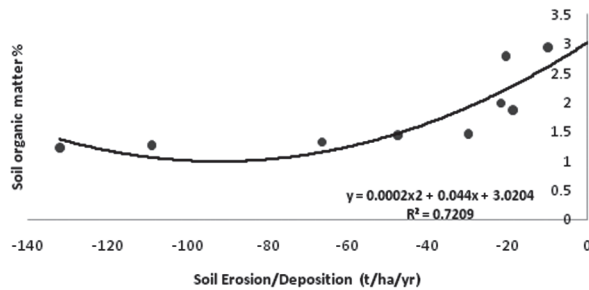


– Sign denotes net soil erosion and + sign denotes net soil deposition

Figure 5. Relationship between soil organic matter percent with rate of soil erosion/deposition in Home gardens

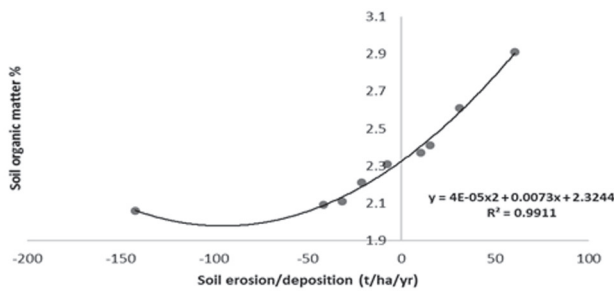
There was a strong negative polynomial relationship exists between rate of soil erosion and organic matter content in the natural forest ($r^2 = 0.92$) and a strong negative linear relationship between rate of soil erosion and organic matter content in home gardens exists ($r^2 = 0.97$) (Figure. 4 and 5). Soil organic matter is mainly confined to 120

top soil layers and moved with eroded soil. Multi-layer canopy system of natural forest and home gardens provide thick litter layer and allows soil movement at slower rate. Therefore, there may be a strong relationship between soil erosion/deposition with soil organic carbon content. Also it may be possible to calculate the movement of surface adsorbed nutrients in watersheds from soil erosion data (Ritchie *et al.*, 1973).



– Sign denotes net soil erosion and + sign denotes net soil deposition

Figure. 6. Relationship between soil organic matter percent with rate of soil erosion/ deposition in shifting cultivation



– Sign denotes net soil erosion and + sign denotes net soil deposition

Figure. 7. Relationship between soil organic matter percent with rate of soil erosion/ deposition in plantation forest

Strong negative polynomial relationship between soil organic matter content and soil erosion/deposition in land uses of plantation forest ($R^2 = 0.99$) (Figure 6) and shifting cultivation ($R^2 = 0.72$) (Figure. 7) was also observed. Under mild soil deposition or mild soil erosion conditions, rapid changes of soil organic matter content was observed with the mild changes of soil erosion and deposition in both plantation forest and shifting vegetable cultivation fields. However, under severe soil erosion conditions, soil organic

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matter content was changed at slower rate. Organic matter rich top soil might get eroded at the initial stage of soil erosion in plantation forest and shifting cultivation fields, where ground cover is minimum compared to natural forest and home gardens. Therefore, higher rate of organic matter loss from top soil might have occurred at mild erosion/deposition conditions in plantation forest and shifting cultivation fields. However, when the rate of erosion is severe, soil erosion might have occurred in sub soil (as top soil might have already got eroded) where organic matter content is comparatively less. Soil erosion breaks down water stable aggregates, thus leading to encapsulated C prone to mineralization (Lal, 2003). Being a selective process, soil erosion also preferentially transfers materials of fine sized particles and light density particles. As a consequence, eroded soil materials that are enriched in organic matter are moved unevenly and deposited at low-lying areas (Boix-Fayos *et al.*, 2009).

CONCLUSIONS

Rate of soil erosion is negatively correlated with soil organic matter content of land uses studied. As soil erosion rates in plantation forests, home gardens and shifting cultivation fields exceed the tolerable limit, soil conservation measures are needed to minimize the soil erosion. As sediment deposition is observed in natural forests, it can be effectively use as barriers for soil erosion in catchments.

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