

Land Use Impact in River Njoro Watershed

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Abstract

The study was done to assess surface runoff and soil erosion in the River Njoro watershed. The study was carried out on runoff plots. A rainfall simulator having dimensions of 0.4 m by 0.25m was used to simulate rainfall on plot size of 0.1m² in five land use areas at an average rate of 10mm/h. Surface runoff and soil erosion generated from the three sites in each land use were measured. The soil properties including bulk density, texture organic matter content and pH were measured in every site. The highest surface runoff was on grazing land and decreased in the order of agricultural land, deforested area, plantation forest and indigenous forest land use. The values of the mean surface runoff in mm for each land use were 23.78, 18.74, 17.72, 6.99 and 0.31 respectively. Soil erosion decreased in the order, agricultural land, deforested area, grazing land, plantation forest and indigenous forest land use. Statistical analysis ($P < 0.05$) showed that there were significant differences in the measured parameters between the land use areas. The results of this assessment are to be used in developing River Njoro watershed management strategy.

Introduction

In River Njoro watershed, once forested areas have been replaced by fragmented landscape composed of remnant forest patches, advanced and emerging secondary vegetation, grassland, tree plantations and highly compacted surfaces including roads, paths and housing units. The fragmentation resulted from decades of forest clearing for fuelwood and timber for construction, increased agricultural activities and overgrazing. This was often done in disregard of conservation measures.

These have led to hydrological modifications resulting in increased runoff and soil erosion in the upper parts of River Njoro watershed. The main indicator of erosion in the watershed is silt deposit in flat areas and along the river channel where the gradient is less steep. Sedimentation causes the river to decrease in depth thereby making the water to overflow the banks even in less intense storms and the river to dry up in dry seasons. As a result, water scarcity has been experienced in the lower parts of the watershed in the dry seasons. River Njoro is currently a major contributor to the sediment load in Lake Nakuru, thus threatening the lake's biodiversity. Consequently, the need to investigate areas of the watershed with high potential of runoff and sediment generation became imperative.

Materials and Methods

Study Area

The study area is River Njoro watershed (0⁰15'S, 0⁰25'S, 35⁰50'E, 36⁰05'E) in Nakuru district, Kenya. It is drained by the River Njoro, which originates from Eastern Mau hills (2700 m.a.s.l.) and drains a total area of 250 km². The river, 50km long, discharges into Lake Nakuru (1700 m.a.s.l.)

The soils and geology of the area are influenced by the volcanic nature of the Rift valley. The River Njoro watershed is covered by loamy soil in the upper forested

parts having developed from ashes and other pyroclastic rocks of recent volcanoes (Ralph and Helmidt, 1984) and deep to deep well drained to moderately deep loamy sandy clays (vitric andosols). The lower reaches are covered by erosive lacustrine soils (Chemilil, 1995). Average annual rainfall is 1200 mm, distributed trimodally with peaks in April, August and November.

Land cover detection using Landsat Satellite Imagery by Baldyga (2004) shows a rapid loss of forest cover in the upper reaches of river Njoro watershed. Plantation and Indigenous forest cover have been lost to other land uses by 9% and 10% respectively in the period between 1986 and 2003. A 6 % reduction in the large scale farms in the area has been noted. In the same period, there has been an increase of 26% in land area used for small scale agriculture and pasture.

Rainfall Simulator

The portable field rainfall simulator used in the study had the dimensions of 0.4m x 0.25m to give a plot size of 0.1m² (Kamphorst, 1987).

Procedure

The study was carried out on runoff plots on 20% slopes, which were used to assess soil erosion and surface runoff in river Njoro watershed in Kenya. The study was done on a randomized block design with five land use treatments and three replicates (sites) per treatment. The sites were mapped using GPS and plotted in a GIS environment. On every study site, rainfall was applied at an average rate of 10 mm/h on the three plots using the rainfall simulator. Soil loss and surface runoff generated from the three plots of every site of different land uses were measured. The soil characteristics including, bulk density, organic matter content, texture and pH were measured at each experimental site.

Statistical Methods

Data on soil loss, runoff, bulk density, organic matter content and pH were subjected to statistical analysis in the computer using STATISTICA for windows (Statsoft, 2001). The source of variation for each component was estimated using a Randomised Complete Block Design (RCBD) (Steel and Torrie, 1980). The value for an individual variable (Y_{ij}) can be explained by the ideal statistical model,

$$Y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$$

Where

μ = represents the overall mean

τ_i = effect of land use

β_j = effects of sites

ε_{ij} = random error component

Analysis of Variance (F statistics) was used to test whether component means were significantly different at the 0.05 level within the land uses and within the sites. The significance of the difference among means was evaluated using Duncan Multiple Range Test (DMRT) after the analysis of variance testing.

Results

Table 1 presents the results obtained from following the procedure described above. The data on soil loss, runoff and other soil properties were recorded. Soil loss decreased in the order agricultural land, deforested land, grazing land, plantation forest and nil in Indigenous forest. There were significant differences ($p < 0.05$) between agriculture land use and all other land uses. The mean values for surface runoff in mm for the grazing, agriculture, deforested land, plantation forest and indigenous forest were, mm for each land use were 23.78, 18.74, 17.72, 6.99 and 0.31 respectively. Grazing land recorded the highest surface runoff while indigenous forest recorded the least.

Table 1: Mean soil loss and soil properties for the five land use types in Upper River Njoro watershed

Land use	Bulk density (g/cm ³)	Organic matter (%)	Soil pH	Soil Texture	Mean surface runoff (mm)	Mean soil loss (g/0.1m ²)
Agriculture	0.85	5.6	6.2	Clay loam	18.74	86
Grazing	1.05	5.0	5.9	Clay loam	23.78	18
Plantation	0.95	6.2	6.4	Clay loam	6.99	2
Deforested	0.78	10.1	5.8	Sandy clay loam	17.72	32
Indigenous forest	0.74	9.5	6.2	Sandy clay loam	0.31	0

Discussion

It is evident from this study that surface runoff and soil erosion were largely influenced by the watershed management conditions. The forested land use types, namely, the indigenous forest and plantation forest, recorded the lowest surface runoff and soil loss. The land use types characterized by intensive interference of land cover and soil surface conditions like agriculture, grazing and deforested areas recorded high runoff and soil loss values.

According to the results of this study, soil loss was highest in agricultural land use type in River Njoro watershed. Many studies (Ziegler et al, 2000; Castillo, 1997) have shown that high run off is consistent with high soil losses. In this study, agricultural land use had notably high mean runoff second only to grazing land. High runoff in agricultural land use led to high soil losses. The major contributor of high soil loss in agricultural land was tillage, which detached a generous supply of loose aggregates and soil particles. The relatively low organic matter content of agricultural land use led to the detachability of soil particles and consequently high soil losses.

Forested land use types (indigenous and plantation) are undoubtedly the best in terms of soil erosion control. These areas recorded the lowest soil losses. This was due to surface cover conditions, which led to high infiltration, less runoff, relatively high organic matter and low bulk density especially for the indigenous forest land use type.

This study had identified agriculture, grazing and deforested land use types as the main cause of the erosion problem. From the results of this study, it can be argued that by maintaining and/or increasing the forest cover, surface runoff and soil erosion will reduce. Increasing the forest cover through afforestation and reforestation programmes should be a priority for the stakeholders in the watershed.

References

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