Assessment of the Impact of Different Vegetation as Riparian Zones in Controlling Nutrients and Sediment Flow Into Water Bodies

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Abstract

In this case study nutrients and sediment were considered to be an important water quality concern in Nyangores Catchment in the larger Upper Mara Catchment shown in figure 1 due to high eutrophication of the river as is evident at some sections of the river. Nitrogen and Phosphorous originates from inorganic and organic fertilizer that affect the river water quality due to intensive agricultural farming and livestock grazing. Increased fertilizer application has enlarged N and P nutrient burden into the river through runoff leading to pollution and consequently eutrophication.Three plots of different vegetations were set up to represent different scenarios of riparian vegetation. Plots representing natural forest, grassland and bare land a distance of twenty meters apart to avoid disparity , were set up to determine their effectiveness in controlling the nutrients. The plots each measured 2m by 10m were set up for Natural forest, bare ground and grassland field. Runoff samples were collected from the plots on rainy days, and taken to the laboratory for Ph, Ec, NO_3 and PO_4 analysis. From the samples analysis the results showed the Ph for the natural forest, bareland and grassland were 7.0, 6.8, and 6.5 respectively, for the nitrates were natural forest 0.20 mg/l, bareland 0.5 mg/l, grassland 0.3 mg/l for phosphates forest it was 0.01gm/l for bareland it was 0.57 mg/l and for grassland 0.55 mg/l. For the Electrical conductivity, forest gave 0.4 mhos, bareland 0.5 mhos and 0.2 mhos for grassland. There is a clear indication that Natural forest on top of controlling the Ph and Ec better than grassland, it has a natural sink for nitrates and phosphate. It is therefore recommended that natural forests be reserved and that grass should be used as an alternative for riparian zones.

Key words: Riparian, Nutrients, Water quality, Water bodies.

1. INTRODCTION

The riparian zone generally encompasses the vegetated strip of land that extends along streams and rivers and is therefore the interface between terrestrial and aquatic ecosystems (Gregory et al. 1991, Martin et al. 1999). In addition to streams and rivers, the definition of riparian zones in the literature often includes the banks of lakes, reservoirs and wetlands. The riparian zone is the land beside the stream that interacts with runoff from hillslopes and stream water when this overflows into the floodplain. The vegetated riparian zone can affect the stream by intercepting runoff, and thereby improving water quality, by providing shade, leaf matter and wood, and stabilizing stream banks.Riparian buffer zones are often advocated as environmental management tools for reducing impacts of land use activities on aquatic resources. The buffer zone, area, or strip is generally regarded as the strip of land that separates an upland or hillslope area from streams, lakes or wetlands. Land use activity is modified in this zone to prevent adverse effects on the water quality, biota and habitat within the watercourse. Buffer zones or strips have also been variously labelled as Stream Protection Zones (SPZ), Streamside Management Zones (SMZ), or Riparian Management Zones (RMZ). In agricultural landscapes, buffer zones often consist of a fenced area alongside streams that stock are excluded from and this may be left as a grass land, or planted with woody vegetation.

The riparian ecosystem is usually measured in terms of watershed level function, because of the ability to filter out large quantities of sediments, nutrients, pesticides, animal wastes, and other nonpoint source pollution (Obedzinski et al., 2001). Riparian vegetation influences light penetration, air and water temperatures, and trophic interactions as the transition between aquatic and terrestrial zones. Large woody debris and litter associated with riparian vegetation are often necessary for productive fish habitats, and influence the physical, chemical, and biotic characteristic of riparian and instream ecosystems (Naiman et al., 1992). However, in some riparian ecosystems, herbaceous plants provide the functions supplied by woody plants in other locations (Baker et al., 2004).

Sedimentation increases turbidity and contributes to rapid siltation of water bodies, negatively impacting water quality. Increased sediment loads also narrow channel widths and provide substrate for colonization of invasive aquatic plant species. Intact riparian buffers ameliorate these negative impacts by stabilizing stream banks.

Roots of riparian vegetation deflect wave action and hold bank soil together. The buffer vegetation also decreases erosional impacts during flood events and prevents undercutting of stream banks. Excess nitrogen and phosphorous from fertilizers and animal waste, as well as other pollutants originating from pesticides and herbicides, often bond to soil particles. The nutrient-loaded sediment contained in surface runoff then flows to the nearest water body and is deposited. This process is the primary cause of accelerated eutrophication of lakes and rivers. Streamside forests function as filters, transformers, and sinks for harmful nutrients and pollutants. Buffer plants slow sediment-laden runoff and depending upon their width and vegetational complexity, may deposit or absorb 50 to 100% of sediments as well as the nutrients and pollutants attached to them (Broadmeadow, S. and Nisbet, T.R. 2004). When surface water runoff is filtered by the riparian buffer approximately 80 to 85% of phosphorous is captured (Gregory,S.V.et al 1991). Nitrogen and other pollutants can be transformed by chemical and biological soil activity into less harmful substances. In addition, riparian plants act as sinks, absorbing and storing excess water, nutrients, and pollutants that would otherwise flow into the river, reducing water quality. One of the most important functions of riparian buffers is enhanced infiltration of surface runoff. Riparian vegetation in the buffer surrounding a water body increases surface roughness and slows overland flows. Water is more easily absorbed and allows for groundwater recharge. These slower flows also regulate the volume of water entering rivers and streams, thereby minimizing flood events and scouring of the streambed.

With the increase of human population at an annual rate of 7% within the basin and the 55% increase in agricultural land in the last 14 years, the Mara Basin has been under constant pressure (Mati et al., 2005). According to different studies, these anthropogenic activities have led to a continuous trend of degradation and faster loss of vegetation, especially in the upper catchments, and consequently the reduction in the quantity and probably quality of the rivers within the Mara River and its tributaries (Matiet al., 2005, Mutie et al., 2006,Mati et al., 2008, Dali, 2007). As a result, there is a tremendous need for thorough evaluation of the current ecological, biophysical and hydrological status of the river ecosystem and development of proper protocols for its management. Figure 1 shows the location of Nyangores River Catchment which constitute part of the upper Mara Basin.

Source: Mati et, al. (2005)

Figure 1: Shows the Larger Mara Catchment with Nyangores Catchment at the Upper Section

2. METHODOLOGY

2.1. Setting of the Runoff Plots

Runoff plots each measuring 10 m long by 2 m wide were set out for the three scenarios i.e. Natural forest, bare land and the grassland. The borders of the plots were made by constructing embankment around the plots. The embankments were lined with plastic papers to prevent seepage. The collector troughs were fabricated using galvanized iron sheets and were installed at a lower end of the runoff plots. A sedimentation tank of 100litres was installed in a hole dug at the end of each plot .A cutoff drain was dug in the area adjacent to the upslope end border of the plots to intercept runoff from the upper catchment area. The setting of the plots was done with the help of the community around the Nyangores river catchment. Runoff Samples were taken ten minutes after the rainfall started. They samples were well preserved with concentrated sulphuric acid and taken to JKUAT laboratories for Ph, EC, No_3 and Po_4 determination. The location of the plots is shown in **Figure 2** below, with coordinates shown in **Table 1**.

Table 1: Shows coordinates of the Runoff Plots

Bareland	Grassland	Forestland
S 00.717 61 E 035 352 29	S 00.717 72 E 035.352 37	S 00.717 96 E 035.351 89

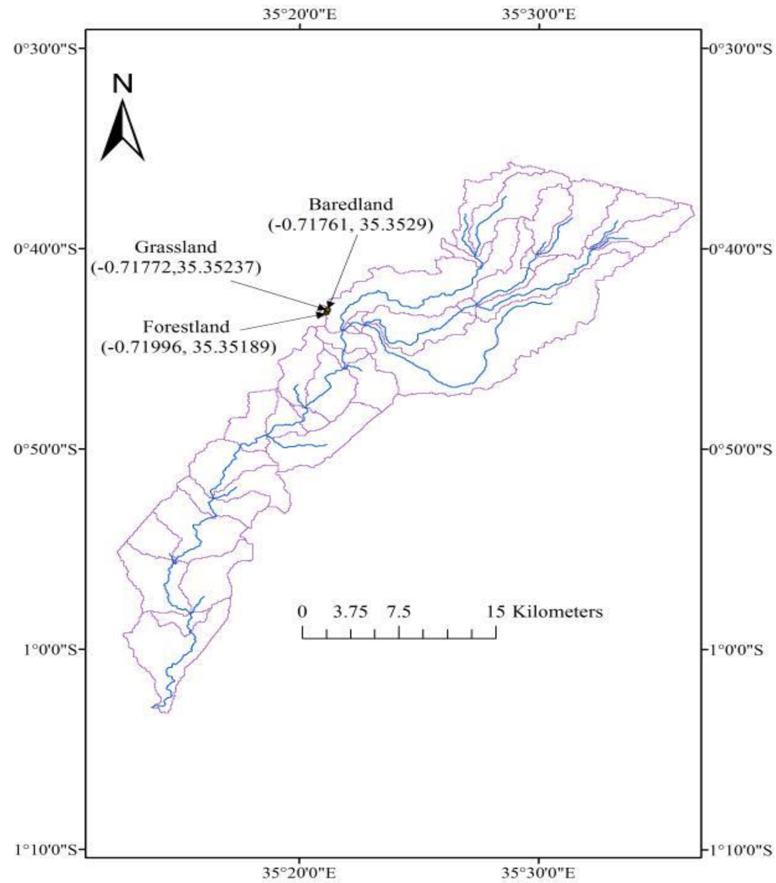

Figure 2 : Shows the Location of the Sampling Plots Within Nyangores River Catchment

The locations were choose to be very close to avoid major disparity in slope and variations in soil types.

2.2. Soil and Water Analysing

Soil was collected from the three scenarios and a particle size analysis carried out to every sample to determine the soil type and other parameters. **Table 2** shows the method used to analyse the soil and water in the laboratory.

Table 2: Laboratory Method Used for Soil/Water Chemical Analysis

S/NO	PARAMETER	METHOD OF ANALYSIS
1	P ppm	Colorimetry at 400 nm OR Uv-Vis-spectrometer
2	NO_3ppm	Colorimetry at 400 nm OR Uv-Vis-spectrometer
3	% TOC	Walkley and Black rapid titration method
4	Soil Texture	Hydrometer Method and Textural triangle
5	Ph H_2O 2:5	Electric pH Meter Method
6	Ec H_2O 2:5	Electric Conductivity Meter Method

3. RESULTS AND DISCUSSION

After the analysis of the runoff samples collected from the three different plots i.e. natural forest, bareland and grassland. The results obtained
are shown in **Table 3** below.

Table 3: Results of Parameters Obtained from Runoff Analysis from the Three Different Scenarios

S/NO	DATE	Natural Forest					Bareland					Grass land				
		Ph	EC mhos	No_3 mg/l	Po_4 mg/l	TSS mg/l	Ph	EC mhos	No_3 mg/l	Po_4 mg/l	TSS mg/l	Ph	EC mhos	No_3 mg/l	Po_4 mg/l	TSS mg/l
1	7/5/16	7	0.03	2.7	0.12	1496	6.7	0.23	0.1	0.11	1952	6.7	0.07	0.25	0.25	55
2	9/5/16	6.8	0.03	1.5	0.11	1554	6.6	0.11	0.2	0.12	220	6.5	0.04	0.22	0.2	60
3	11/5/16	7.1	0.05	0.6	0.13	1677	6.7	0.07	0.3	0.1	266	6.3	0.04	0.25	0.15	65
4	13/5/16	7	0.05	0.5	0.1	1827	6.7	0.06	0.22	0.15	0	6.2	0.03	0.26	0.09	50
5	15/5/16	6.9	0.04	0.2	0.12	1418	6.8	0.05	0.5	0.1	252	6.5	0.02	0.3	0.1	78
6	17/5/16	7	0.04	0.25	0.15	2038	6.8	0.05	0.5	0.1	245	6.3	0.02	0.3	0.1	44
7	19/5/16	6.9	0.03	0.3	0.01	1418	6	0.03	0.4	0.23	252	6.2	0.01	0.35	0.12	78
8	21/5/16	7	0.03	0.37	0.09	260	6.6	0.01	0.45	0.19	240	6.3	0.01	0.52	0.33	100
9	23/5/16	7.2	0.04	0.35	0.12	256	6.5	0.02	0.47	0.2	220	6.8	0.01	0.53	0.18	115
10	25/5/16	7	0.07	0.3	0.15	250	5.9	0.06	0.5	0.16	253	6.8	0.02	0.52	0.02	120
11	27/5/16	7	0.03	0.3	0.01	286	6.8	0.16	0.16	0.57	267	6	0.06	0.5	0.55	132

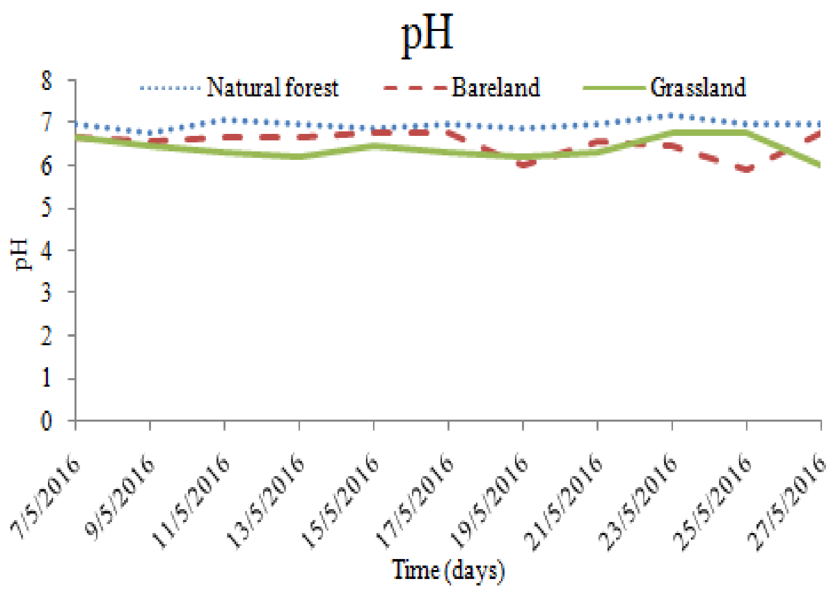

Figure 3: Shows the PH Obtained from Samples Taken from the Three Scenarios

PH is a measure of how acidic or basic water is. A pH of 7.0 is neutral, values less than 7.0 are acidic, and those more than 7.0 are basic. The average pH for the forest runoff plot was 7.0 (neutral) which is perfect for aquatic life where as the bare land averaged at 6.0 which is slightly lower than the optimal pH range for aquatic life this is indicated in **Figure 3**. This is a clear indication that natural forest plays a pivotal role in controlling the pH of runoff water. **Figure 4** shows that the average electrical conductivity from the forest was higher at some point compared to other plots which is attributed to the biological activities that takes place on the forest surface.

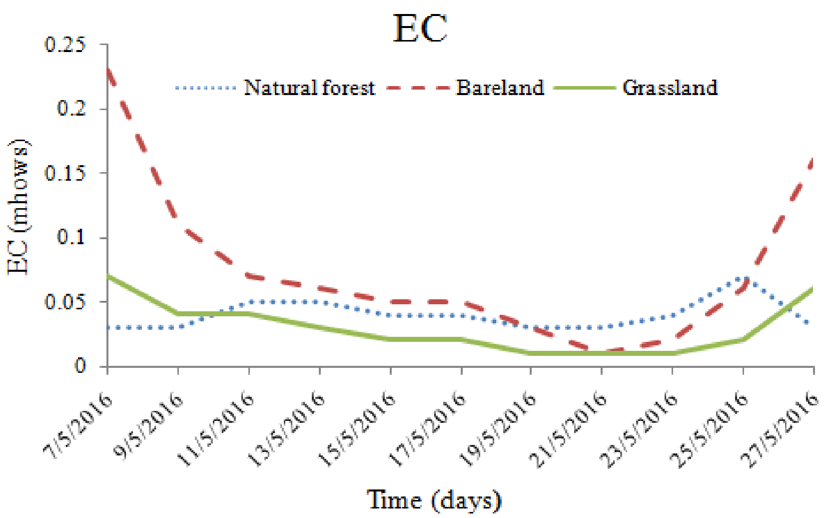

Figure 4: Shows the EC Obtained from Samples Taken from the Three Scenarios

3.1. Grassland

The nutrients are mostly embedded on the soil particles which are carried in the runoff from the three scenarios i.e. **Figure 5** shows that the grassland plot which at date 07/05/2016 the TSS was 55mg/l which reduced to 50mg/l and there was a downward trend up to date 19/05/2016.This can be attributed to the effectiveness with which the grass can trap the sediment. However there was an upward trend from date 20/05/2016, the TSS rising to a whopping 132mg/l. This can be attributed to the concentration of the sediment in the grass allowing top flow over the grass and into the trapping troughs. The grassland initially recorded a high TSS of about 1800 mg/l which gradually decreased to 200mg/l. This can be attributed to washing away of the uncovered top soil through runoff leaving the surface with no loose soil.The phosphates remained high in grassland as compared to other scenarios as shown in **Figure 7.**

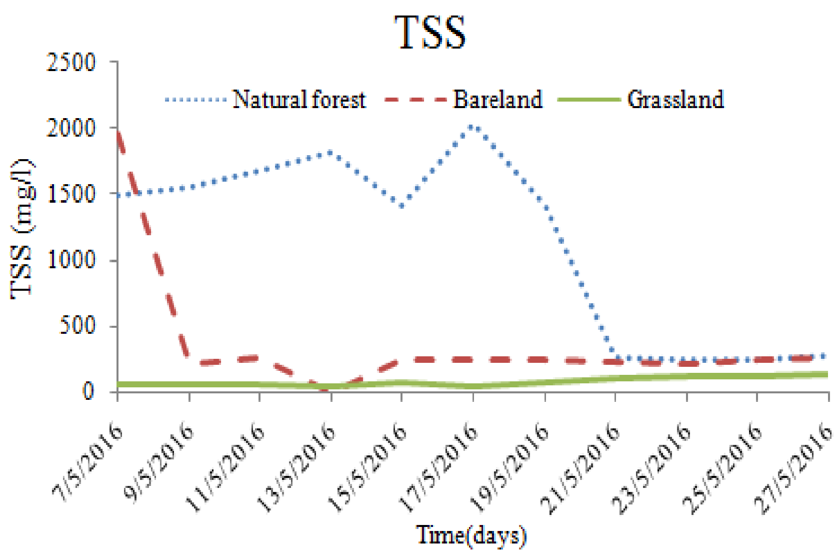

Figure 5: Shows the TSS Obtained from Samples Taken from the Three Scenarios

3.2. Natural Forest

The natural forest scenario started with approximately 1496mg/l at the beginning of the rainfall which increased to 2038mg/l and then declined to 1418mg/l, remaining approximately constant at 250mg/l thereafter. This can be attributed to the effect of the canopy at first in intercepting the rain drops which in turn wet the leaves of the trees. lot of the runoff is infiltrated into the soil due to the litter and debris found in the natural forest. Nitrates in the forest scenario progressively reduced as shown in **Figure 6**.This could be attributed to the biological activities within the forest environment such as dinitrification.

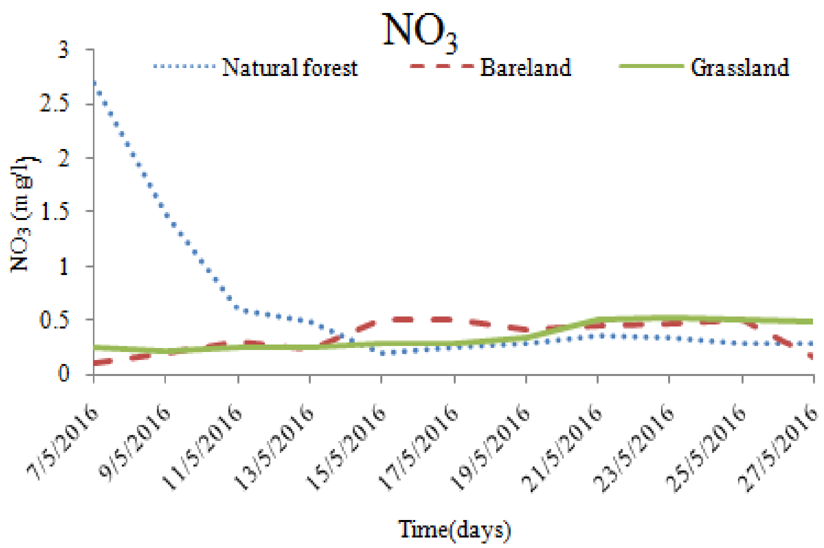

Figure 6 : Shows the NO_3 Obtained from Samples Taken from the Three Scenarios

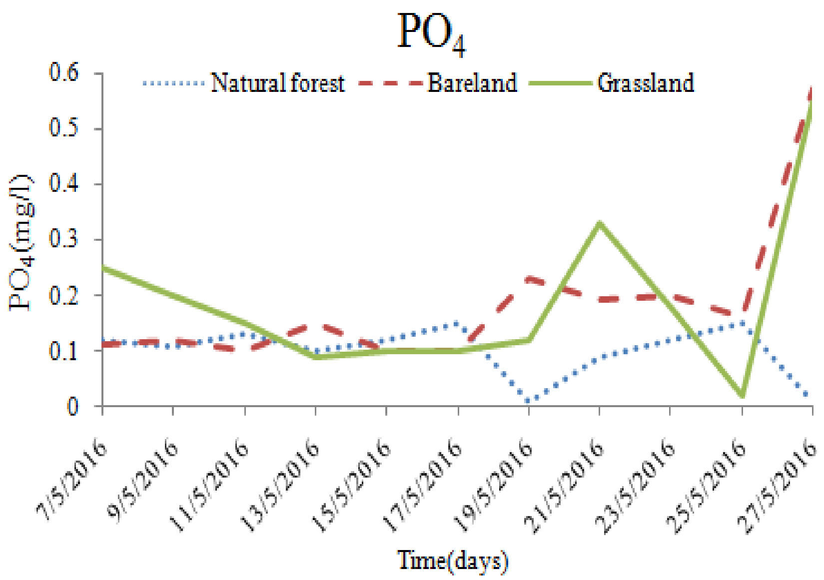

Figure 7: Shows the PO_4 Obtained from Samples Taken from the Three Scenarios

3.3. Bareland

The suspended sediment from bareland which at date 7/5/2016 started with 1845mg/l which increased to 2000mg/l at date 16/5/2016 and reduced considerably to 250mg/l at date 17/5/2016 to 19/5/2016 and thereafter remained the same. This can be attributed to the washing away of the top soil resulting in a runoff heavily laden with sediment which reduces progressively with continuation of rainfall.

4. RECOMMENDATION AND CONCLUSIONS

Riparian management can be viewed as a last line of defense for attenuating contaminants before entering the stream. Fencing stock out of streams and retiring riparian margins from agricultural land use are also particularly important practices to improve stream water quality. Riparian management can take various forms such as fencing strip of rank paddock grasses to filter nutrients and sediment. Fencing wetlands as hotspots for nutrient removal. Filter strips with varied stock grazing practices, such as occasional light grazing by sheep. Plant buffer of native trees to return ecological function to the stream and provide water quality benefits. Buffer of forestry trees should be left unharvested along stream banks or practice production of trees that are planted in riparian zones for selective harvesting with minimal disturbance.

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