ASSESSMENT OF THE STATUS OF SOIL MACRO-ELEMENTS ALONG A GULLY AT FARM KRUMHUK, KHOMAS REGION, NAMIBIA (2007)

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ABSTRACT

Soil erosion in agricultural systems presents problems that are very difficult to deal with, as nutrient-rich topsoil is eroded, silting into lakes, reservoirs and rivers, and causing environmental problems.

This research, conducted at Krumhuk, a farm surrounded by mountains, is ongoing, maps erosion of a gully and conducts a change-detection analysis of the gully. It also assesses the macro-elements of soils- and vegetation-cover changes along the gully. Mountain landscapes such as those found within this farm normally experience water erosion during the rainy season. However, despite the general recognition of how this problem affects agricultural productivity, there are few studies to quantify the extent of macro-element loss. This study therefore assesses responses of macro-elements [phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na)] to water erosion along the gully. Methods used are Landscape Function Analysis (LFA) and soil analysis.

The main hypothesis of the study is that there is a reduction of macro-elements in response to water erosion, and this results in deficiencies of nutrients along the bottom of the gully as compared with the outside of the gully. The results show a poor nutrients cycle and low macro-elements along the bottom of the gully in comparison with the condition of the outside of the gully. This impoverishment is attributable to loss of elements along with the water-eroded topsoil.

The final soil sampling is set to be completed in November 2008. Results presented in this article will be used as the baseline for comparison with the situation a year later.

INTRODUCTION

Monitoring landscape 'health' over time, in response to environmental, management or regulatory drivers, has importance for both private and public land managers, especially when the monitoring output has direct relevance for management decision-making (Tongway and Hindley, 2004). The adverse effects of soil erosion in agricultural systems are problematic. According to Cullen (2006), major concentrations of high-velocity run-off water in larger gullies remove vast amounts of soil. In the process of soil erosion, nutrients-rich topsoil is lost, which also causes environmental problems that result from siltation of lakes, reservoirs and rivers (Zengxiang *et al.*,1996; Kokh-Shrestha, 2005).

Apart from run-off water erosion, wind erosion is also a major constraint in the north and central regions of the country (Namibia), due to the decrease in the vegetation cover and also to the dearth of trees that results from over-cultivation of larger fields (Keib, 2006). The central region, in particular, faces problems of soil erosion by water because of its mountainous landscapes. Farm Krumhuk, located to the south of Windhoek, is surrounded by mountainous landscapes that normally experience water erosion during the rainy season; every year the topsoil is washed away during the rainy season. However, despite the general recognition of the problem that water erosion and its impacts presents for the agricultural productivity, there are few studies to quantify the extent of macro-elements lost along with the topsoil of a mountainous area.

This study assesses responses of macro-elements [phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na)] to water erosion along a gully. The main hypothesis of the study is that there is a reduction of macro-elements in response to water erosion, resulting in deficiencies of nutrients along the bottom of the gully as compared with the outside of the gully. Results presented in this article will be used as the baseline for comparison with the situation a year later.

STUDY AREA

Introduction

The Republic of Namibia, with a land surface of 824 268 km^2, is situated along the south Atlantic coast of Africa, between 17 and 29 degrees south of the equator. This research is a farm-level study undertaken on Farm Krumhuk in the Khomas region in the central part of Namibia. Farm Krumhuk, consisting of 8450 ha 20 km to the south of Windhoek, is surrounded by mountainous landscapes. It is situated at latitude [degree minute second (DMS)] 22°44'38" S and longitude (DMS) 17°4'20" E. The area was selected because of its mountainous landscape, water-erosion problems and the partnership in using the farm for the practical training of agricultural students from the Department of Agriculture, Polytechnic of Namibia.

Rainfall

Namibia is classified as the driest country in sub-Saharan Africa (Elsevier, 1989; Du Pisani, 1997). It has a variable and unpredictable climate that is subject to great temporal and spatial perturbations in rainfall patterns. Rainfall is highly seasonal. The mean annual rainfall at Farm Krumhuk is 288 mm, 90 % of which occurs during the summer months of October to February, whereas there is no rainfall in the winter months. The rainfall is not only low but also highly variable and unpredictable over time and space. Figure 1 shows the variations in rainfall over a period of nine years (1993/1994 to 2001/2002 seasons).

Soil

The landform of the area is mountainous, with a general altitude range of 1400 m to 2000 m (De Pauw *et al.*, 2001). According to De Pauw *et al.*, the farm is within a regional slope of 15 % to 60 %, with a very high relative relief of > 300 m and a weakly oriented drainage pattern, and with metamorphic and granitic rocks. The Farm Krumhuk soil is, according to the 1:1 million scale Soil Map of Namibia, 50 % Eutric Leptosols, with shallow soils, loamy topsoil, and fair to good nutrient status; while the other 50 % is Rock (De Pauw *et al.*, 2001). The soil has been ranked fifth in terms of agricultural potential and the area is suitable for large stock grazing.

Depth of the Gully (June 2007)

The gully was selected for the farm owner's technical knowledge of the site. Figure 2 shows a cross-section of the gully system at four different transects. Transect one and two show the gully confluence depth at 118 cm and 107 cm, and at 167 cm and 95 cm respectively. The gully depth for transects three and four was 207 cm and 180 cm.

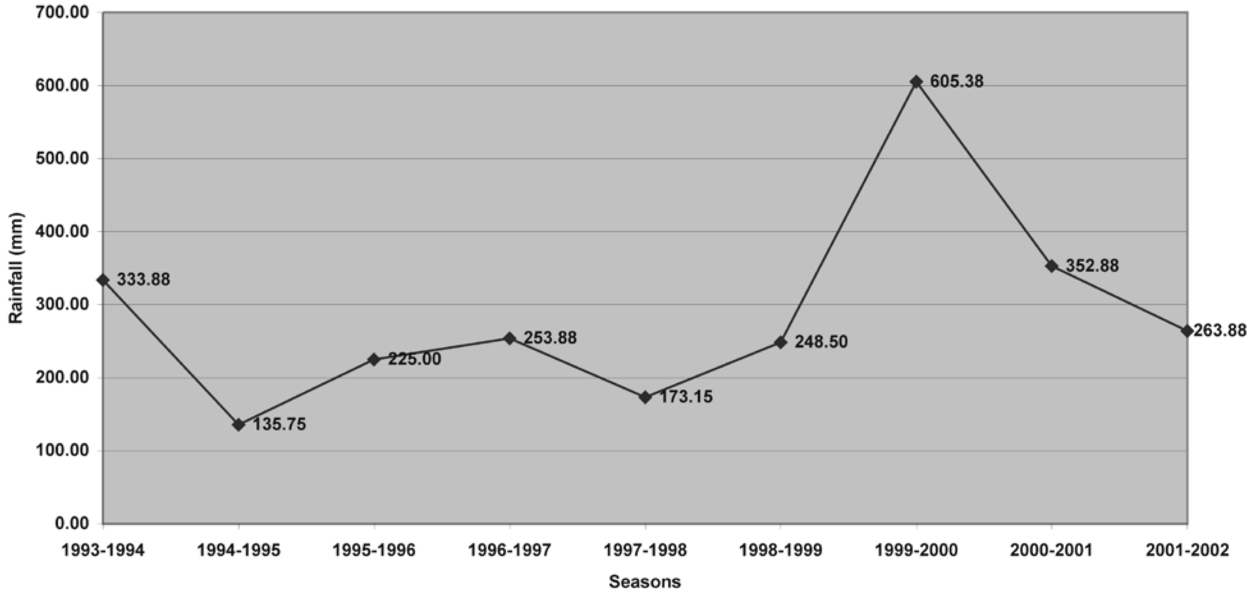

Figure 1. Annual Rainfall totals (1992–2003) (Krumhuk Station). Source: farm owner Voigts, U-D., 2007.

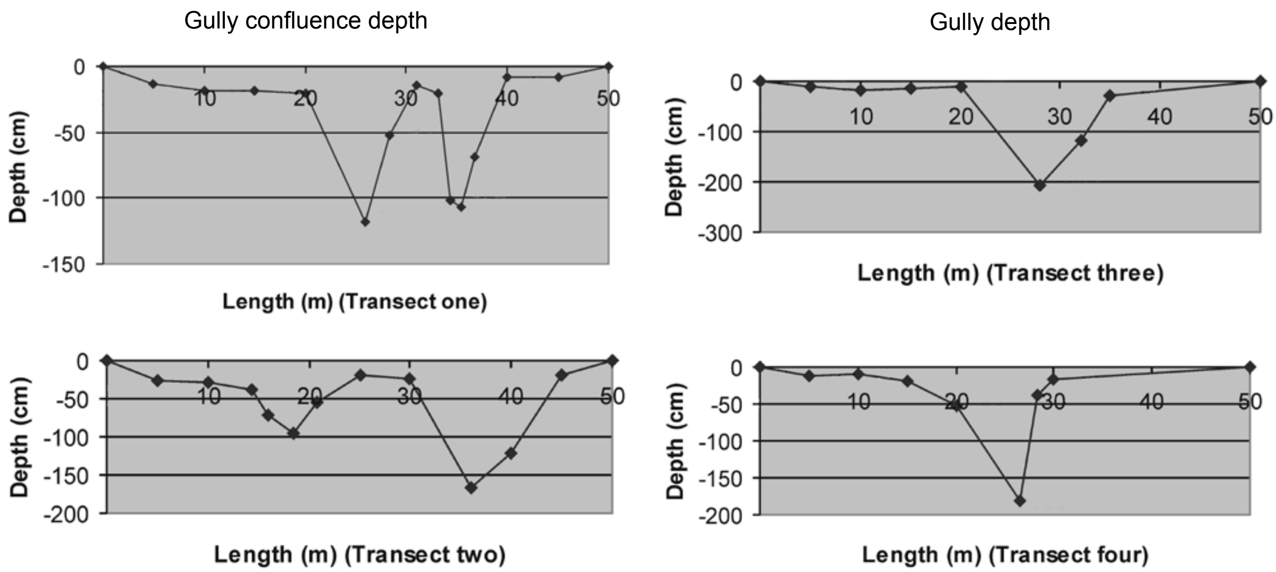

Figure 2. Gully depth at various sites.

METHODS

Four transects along the gully under investigation were measured in June 2007. Depth was measured with a tape measure in centimetres. Functionality of the soil was measured by Landscape Function Analysis (LFA) (Tongway and Hindley, 2004). At each transect the patch and inter-patch zones were identified and LFA indices measured. These indices were then interpreted to quantify infiltration, nutrients and stability of the soil. The collected data for LFA were inserted into the LFA template, which calculates and plots the data on the graphs automatically.

Nine soil samples were collected along each transect. Soil samples were taken with a soil auger at a depth of 20 cm at 5 m intervals from the start and then 10 m intervals to the end. The soil samples were analysed at the Agriculture Laboratory of the Ministry of Agriculture, Water and Forestry, Windhoek, Namibia (Dausas, 2007), for macro-elements such as P, K, Ca, Mg and Na, and pH (water), electrical conductivity and organic matter. At this stage nitrogen is still to be analysed, due to unavailability of materials at the laboratory.

RESULTS

Nutrients status – LFA results

Figure 3 indicates the average individual contributions to the nutrient status and nutrient cycle of each patch type. The stable flank (outside the gully) contributes the highest average nutrients, at 90 %, while along the bottom of the gully nothing is contributed to the nutrient status, hence it recorded zero percent. The stable flank also has the highest average nutrient cycle, at 88 %, while the stripped slope has the lowest, at 13 %.

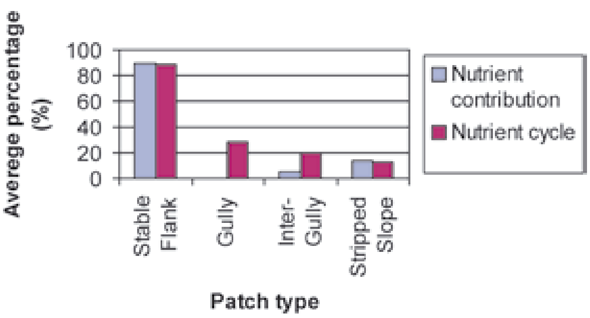

Figure 3. Average nutrient contributions and nutrient cycle of different patch types along the gully.

Macro-elements status – Soil analysis results

Figure 4 shows the average macro-elements along the gully. It indicates that most elements under investigation (P, K, Ca, Mg and Na) are very low (parts per million (ppm)) along the bottom of the gully as compared with the outside of the gully. For example, the average of Ca is highest, at 548 ppm, on the outside of the gully and low, at 235 ppm, along the bottom of the gully respectively.

CONCLUSION

The results obtained from the LFA show that there is a better nutrient cycle along the stable flank (outside of the gully) and a poor nutrient cycle along the stripped slope. The stable flank contributes more to the soil nutrients, while along the bottom of the gully there is no contribution at all to soil nutrients. The result obtained from the soil analysis indicates that most of the elements (P, K, Ca, Mg and Na) are very low (ppm) along the bottom of the gully while relatively high on the outside of the gully.

It can therefore be concluded that the poor nutrient cycle and lower availability of elements along the bottom of the gully are attributable to the loss of elements along with the topsoil in the process of water erosion. The stable flank contributes more to the soil nutrients, as less water erosion and loss of topsoil occurred than had been expected. Hence the average contribution of the stable flank to nutrient status is 88 %, and ensures that the nutrients are returned within the zone instead of being depleted.

Therefore, the hypothesis of the study was accepted, which is that there is a reduction of macro-elements in response to water erosion, which results in deficiencies of nutrients along the bottom of the gully as compared with the outside of the gully. Results from the LFA indicated a poor nutrients cycle along the bottom of the gully as compared with the outside of the gully. This is supported by the results of the soil analysis, with elements along the bottom of the gully low as compared with those on the outside of the gully.

The expectation is that results for June 2008 will indicate much greater reduction in macro-elements and a poorer nutrient cycle along the bottom of the gully. The follow-up to this article will be published by the end of 2008.

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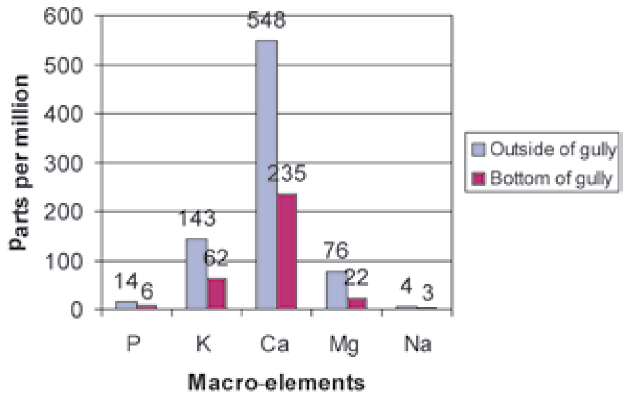

Figure 4. Macro-elements status along the gully.

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