Effect of Declining Rainfall and Anthropogenic Pressures on Three Wetland Types in Lesotho

Olaleye, A.O and Sekaleli, T.S.T
Department of Soil Science & Resource Conservation, The National University of Lesotho, Roma 180, Lesotho

Abstract
An investigation was conducted in three wetland types (Palustrine, Lacustrine & Riverine) in three different agro-ecological zones of Lesotho. The order of anthropogenic impacts were Riverine>Lacustrine>Palustrine. Rainfall data 1936-2006 (i.e. 80 years) were collected and subjected to Cumulative Sum (CUSUM) procedure to analyze increasing or decreasing trends in rainfall. CUSUM showed a decreasing rainfall trend between 1967 and 2006. Organic carbon contents were highest in the undisturbed wetland (Palustrine) and was of the order Palustrine>Lacustrine>Riverine. Highest water soluble N & P in the runoff water was found in the Riverine wetlands and lowest in the Palustrine (<0.01 mg/l of N & P) suggesting increased pollution due to increased anthropogenic activities.

Key words: Anthropogenic pressures, pollution, wetlands, Lesotho

1. Introduction

Lesotho has a total land area of 30, 350km^2 with four distinct agro-ecological zones based on the geology and climate (Table 1). Less than 10% (or 3,035 km^2) of the total land area of Lesotho is classified as arable and the rest is rangeland. There are wetlands occur in all agro-ecological zones (AEZ) and the total land area of approximately 96, 381 ha (Olaleye unpublished). The wetlands found in Lesotho fall under three broad categories, Palustrine, Lacustrine and Riverine. Palustrine wetlands are the dominant type and these include mires (bogs and fens), most of which are found at high altitude. Lacustrine wetlands are found in the artificial lakes, while Riverine wetlands are found along the river valleys and streams. Wetlands in Lesotho support more than 300,000 households through agriculture, fishery and livestock watering activities. There is a growing concern on the rate of degradation of these wetlands due to overgrazing, cropping and discharged of untreated pollutants into these ecosystems, hence they are being degraded. There is sparse information on the nature and physico-chemical characteristics of wetlands of Lesotho, coupled with their constraints and managements. Thus the present investigation aims at comparing the selected characteristics of three wetland types, identifies causes of mismanagement as a result of intensive cropping and overgrazing, anthropogenic pressures and suggests plausible management options for a sustainable and continuous use of these fragile ecosystems for agriculture.

2. Methods

Three wetland types with different levels of anthropogenic impacts in the Lowland and Foot-Hills AEZ were chosen. The Palustrine wetland has low anthropogenic impact, while the Lactustrine and Riverine had medium and high anthropogenic impacts (Chips et al., 2006). A transects (1000m) each were chosen in the Palustrine and Lacustrine wetlands and mini-pits (0.50m) were dug and soil samples collected at intervals of 200m. In the Riverine wetlands, three land use types (LUTs) were identified: wetlands, cropping and grazing/pasture. Soil samples were collected from the transects that runs across these three LUTs.

Table 1. Agro-ecological characteristics of Lesotho

Agro-ecological zones	Area (km2)	Altitude (m) above sea level (asl)	Topography	Mean annual rainfall (mm)	Mean annual Temperature (ºC)
Lowland	5,200	<1800	Flat to gentle	600-900	-11 to 38
Senqu river valley	2,753	1000-2000	Steep sloping	450-600	-5 to 36
Foot-hills	4,588	1800-2000	Steep rolling	900-1000	-8 to 30
Mountains	18,047	2000-3,484	Very steep bare rock and gentle rolling valleys	1000-1300	-8 to 30

Soil samples collected were taken to the laboratory for routine analysis (pH-water, total N, available P, K, Ca, Mg and Na). Runoff water samples were collected from a 50-mls plastic bottles installed on the transect at intervals of 200m. Runoff water samples were analyzed for N & P and heavy metals (Pb, Cd, Cr, As) (APHA, AWWA and WPCF, 1975). Climate (rainfall) data for the nearest to the wetlands were collected between 1926 and 2006 from the Lesotho Metrological Services. These data were subjected to cumulative sum (CUSUM) techniques (Beamish et al. 1999):

$$Cusum = \sum_{t_i}^{t_f} (x_t - \bar{x}) \qquad (1)$$

where xt is the monthly averaged variable at time t (varying between initial t_i and final t_f), and $\bar{x}$ is the variable averaged over the whole period of investigation. In Cusum plots, positive and negative slopes reflect increasing and decreasing trends and it has been used as a tool in detecting intermediate term changes in the mean value of a sequence of regularly spaced observations (Beamish et al. 1999).

3. Results and Discussion

An examination of the CUSUM plot (Fig 1) that showed the rainfall trend between 1926 and 2006 revealed that there are two distinct periods: 1926-1966, where mean rainfall was increasing and between 1967 – 2006, where the mean annual rainfall started decreasing at a decreasing rate. Results showed that there were significant differences in the organic carbon contents within and between these wetlands (Figs 2a-c). A closer observation showed that due to high anthropogenic impacts, the organic carbon was of the following order in the wetland types: Palustrine > Lacustrine > Riverine (Figs 2a-c). Results also showed that the amount of water soluble N & P (See Figs 3a and 3b) were also of the aforementioned order being highest in the Riverine wetlands (Table 2) suggesting high rate of anthropogenic activities in the Riverine wetland. Elevated levels of heavy metals were also observed in one of the Riverine wetlands which were higher than the minimum permissible levels recommended by the World Health Organisation.

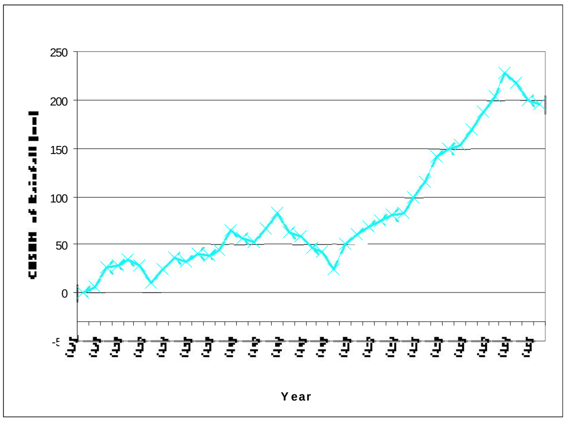
4. Conclusions

Investigations were carried-out in three types of wetlands (Palustrine, Lacustrine and Riverine). Results of the CUSUM showed that as from 1967 till date, the mean annual rainfall has been decreasing at a decreasing rate, hence, most of the groundwater table in these wetlands (especially Lacustrine and Riverine) has declined. The Riverine wetlands have lost most of the indigenous vegetation. In addition, the organic carbon content are low compared with the reference wetlands – Palustrine. There is higher concentrations of N and P in the run-off water (i.e. Lacustrine and Riverine wetlands).

Table 2: Water soluble N & P from the Riverine wetlands

LUTs	**-------P (mg/l)--------**	**--------N (mg/l)--------**
	Nov	Feb
Crop	17.29a*	0.86a
pasture	15.89a	1.143a
Wetlands	23.56b	1.50a

*means with same letter in same column are not significantly different (DMRT) @ 5%



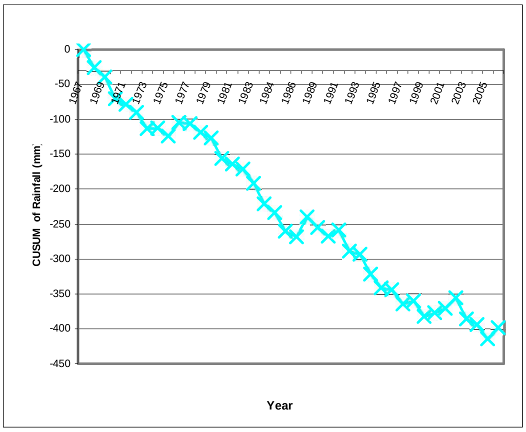


Fig 1: Fig 2: CUSUM Chart between 1926-1966 and 1967-2006

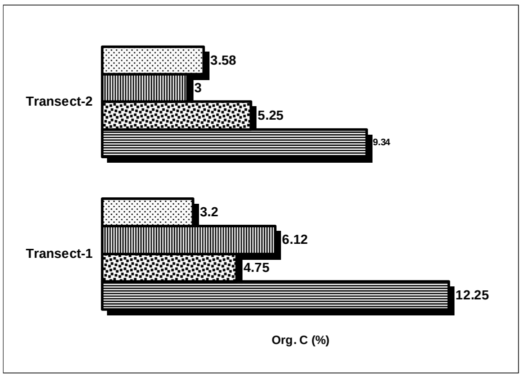


Fig 2a: Organic carbon in Palustrine wetland

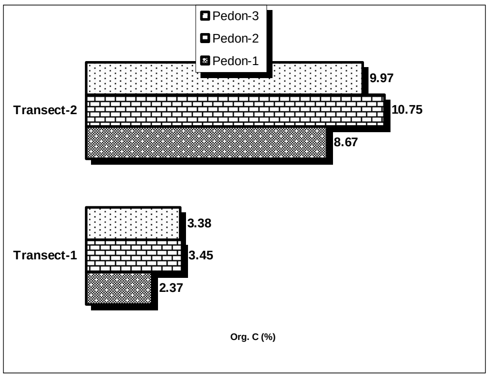


Fig 2b: Organic carbon in Lacustrine wetland

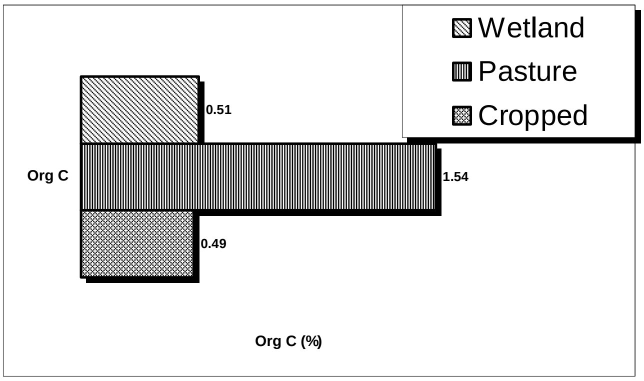


Fig 2c: Organic carbon in Riverine wetland

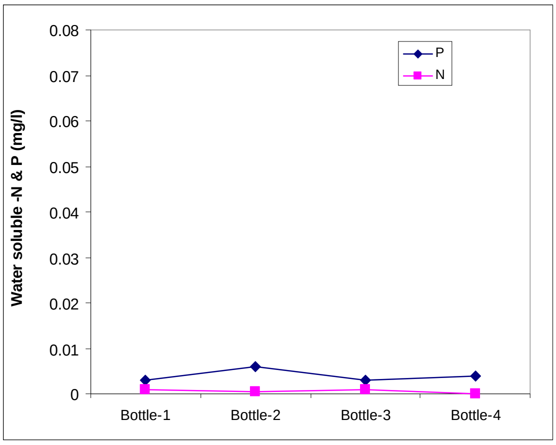


Fig 3a: N & P in runoff water in Palustrine wetlands

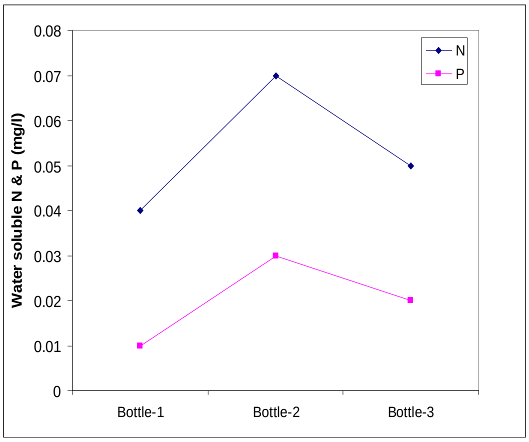


Fig 3b: N & P in runoff water in Lacusrtine wetlands

6. References

American Public health Association, America Water Works Association & Water Pollution Control Federation 1975. Standard methods for the examination of water and waste water. 15th Edition, American Public Health Association, Washington DC. 30p.

Beamish, R. J., D. J. Noakes; G.A. McFarlane; L.K Lyash-Torin, V.V. Ivanov, and V. Kurashov. 1999. The regime concept and natural trends in the production of Pacific salmon. Can. J. Fish. Aquat. Sci. 56: 516–526.

Chips, S.R., Hubbard, D.E., Kent, B., Werlin, N, J. Haugerud, Kipp, A. Plwell, Jo Thompson and Tom Johnson. 2006. Wetlands 26(2): 497-508.