The distribution, characteristics and utilization of wetland soils in Sio Basin, Western Kenya.

S.N.Wanjogu and C.R.K. Njoroge

Kenya Soil Survey, P. O. Box 14733, Nairobi.

Abstract

A rapid assessment of the River Sio Basin Wetland soils was done longitudinally from the source to Lake Victoria. Soil observations were made at randomly selected points in the basin wetlands. The assessment was done in the upper, middle and lower sections of the basins that cover Teso, Busia and Bungoma Districts. The aim of this work was to carry out an assessment of the wetland soils in this basin with a view to: inventorise the wetland soil resource, assess the impact of the activities of local people on the present and future soil status, suggest possible remedies and areas of further research.

The examination of the soils revealed that the soils of the upper sections of Sio are imperfectly drained to poorly drained, very deep, dark grayish brown to black, friable to firm, sandy clay to clay. The top topsoil is in places humic with a 20 cm thick undecomposed or partially decomposed organic matter. The soils are developed on various igneous rocks or colluvial and alluvial materials derived from these rocks. The soils are classified as Cambisols, Vertisols, Planosols and Gleysols.

The soils of the middle section are imperfectly drained to poorly drained, very deep, brown to black, friable to firm, sand to clay. In undisturbed areas, 20-30 cm of undecomposed or partially decomposed organic matter occurred. The soils are classified as Gleysols, Arenosols and Fluvisols while Acrisols occur on the fringes. The soils are developed on alluvial material derived from various sedimentary and igneous rocks.

The soils of the lower section are imperfectly drained to very poorly drained, very deep, dark grayish brown to black, mottled, friable to firm, sandy clay to clay. The soils are classified as Fluvisols, Gleysols and Vertisols. Acrisols occur on the fringes. The soils are developed on alluvial material.

The soils of the upper section occur in valleys and bottomlands while in the middle part they occur in valleys. In the lower section the soils occur in bottomlands and swamps.

The wetlands in the three sections are dominantly used for growing subsistence crops and for grazing at the edges while other utilizations are section specific. The results show that the opening up of a wetland for cultivation without taking into consideration the necessary management and conservation measures (in the wetland and the adjacent uplands), reduces the buffering capacity of the wetland with continued use. Vegetation clearing was observed to have a negative impact on the sieving and buffering capacity of a wetland mainly due to siltation and organic matter depletion.

Introduction

River Sio has its source from foot slopes of Mt. Elgon. The river flows through Bungoma, Teso and Busia Districts. The river has a catchment area of about 1,500 km^2. The length of the river from its source into the Lake Victoria is approximately 80km.

The altitude of the longitudinal cross-section of the river from the source to Lake Victoria ranges from 1140m above sea level (a.s.l) to 1500m (a.s.l) with a drop of about 360m. The longitudinal cross-section of the catchment can be divided into upper, middle and lower sections.

Sio River catchment has a leaf shaped geomorphologic trough that runs south – westward from the foot slopes of Mt. Elgon. The catchment lies between Latitudes 30^0E and 36^0E, and Longitudes 0^oN and 10^oN.

The upper and middle sections of the Sio river catchment receive 1,400mm and 2,000 mm of rainfall per year respectively while the lower section receives approximately 1270 mm mean annual rainfall.

Mean annual temperatures range between 26^0C and 32^0C in the lower section while in the upper and middle sections, mean annual temperatures range from 23^0C to 30^0C. The catchment is in Agro-climatic zones 1 and 11 where the rainfall to potential evaporation ratio is between 65% to and more than 80%, with high to very high potential for plant growth if there are no soil limitations (Sombroek *et al,* 1982)

The wetland soils in Sio river catchment occur in the following physiographic units: valleys, swamps and bottomlands.

The soils of Sio river wetlands are generally imperfectly drained to very poorly drained, very deep, very dark gray to brown mottled, friable to firm, sandy clay to clay. The soils in places are saline and/or sodic, or stratified. The soils are classified as Planosols, Vertisols, Gleysols, Fluvisols, Cambisols, Arenosols and Acrisols. The soils are developed on mudstones, colluvial and alluvial materials derived from various igneous rocks such as granites, basalts, phonolites and tuffs.

The uplands adjacent to the wetland soils have soils which range from excessively drained to moderately well drained shallow to extremely deep, red to dark brown friable to firm, sandy clay loam to clay, in places, the top soil is humic.

Upland soils are developed from Kavirondo sediments (mainly mudstones) and igneous rocks (mainly granites, basalts, phonolites and tuffs) The soils are classified as cambisols, plinthosols, Nitisols, Acrisols and Ferralsols.

In the study area, the Wetland soils occur mainly in low lying areas which include valleys, swamps and bottomlands, but it should be understood that wetland soils can occur on higher parts like foot ridges, foot slopes and mountains. Wetland soils are generally subject to periodic excessive wetness that greatly influences the possibilities of using the soils or are soils that show marks of their environment of formation such as grey colours and mottling which indicate reducing conditions.

The aim of this work was to carry out a very rapid assessment of the wetland soils in the Sio River Catchment with a view to inventorize the wetlands soil resource and assessing, the impact of the activities of the local people on their present and future status and therefore suggest practical remedies

Materials and methods

All the relevant information was collected covering the Sio River catchment. The exploratory soil map of Kenya (Sombroek *et al.,* 1982) together with the 'Soils of Busia' (Rachilo and Michieka, 1996) was studied.

In the field, auger hole observations were randomly made to a depth of 120cm and described following the FAO (1977) "guidelines of soil description". Soil colours were determined using the Munsell Colour Charts (Munsell color Co., 1971). Soil classification (tentative) was done according to the FAO/UNESCO Legend (1990) physical and chemical determinations were done as outlined by Hinga *et al* (1980). A total of 32 observations were made in the wetlands.

Results

The Wetland soils of Sio river catchment occur on valleys, swamps and bottomlands. However, these physiographies can be found at any section of the longitudinal cross-section of the river. Therefore the results and discussion will cover the upper, middle and lower sections of the river catchment (Fig 1).

Upper Sio River Wetlands

The soils are imperfectly drained to poorly drained, very deep dark grayish brown to black, friable to firm, sandy clay to clay. The topsoils are sandy to silty clay loams. The topsoil is humic in some places with 20cm thick under composed and partially decomposed organic matter. The sub soils in places are compact. The soils are developed on colluvial and alluvial material derived from various igneous rocks. The wetland soils are classified as Cambisols, Vertisols, Planosols and Gleysols. Gleysols and Cambisols occur in the valleys while Vertisols and Planosols occur in bottomlands. Bottomland soils are in places sodic and saline. The wetlands are flat to gently undulating with slopes 0-3%. The soils occur in bottomlands and valleys.

Subsistence mixed farming is practiced in these wetlands. The most commonly grown crops are maize, beans, millet, vegetables, arrowroots and sweet potatoes. There are a few commercial sugarcane-growing farms in the area. The wetlands are also used for grazing livestock especially during the dry seasons. Sand harvesting and brick making using wetland soils also takes place in the upper section. Fishing also takes place in the section.

The upper section wetlands are adjacent to uplands with excessively drained to well drained shallow to extremely deep, red to dark brown, friable to firm, sandy clay to clay. In places, the topsoils are humic. The soils are classified as Combisols, Plinthosols, Nitisols, ferralsols and Acrisols. The soils are developed on mainly granites, olivine basalts, nepheline phonolite and basic tuffs.

Middle section Wetland soils

The soils of section are developed on alluvial and colluvial material derived from granites and mudstones. The soils occur in valleys, which are flat to undulating with slopes 0-8%. The soils are imperfectly drained to very poorly drained, very deep, brown (10YR) to black (2.5Y), friable to firm, sand to clay. The soils are stratified near the river. The soils are classified as Fluvisols, Gleysols and Arenosols. The wetlands are cleared for cultivation of maize, bananas, millet, arrowroots, sweet potatoes, vegetables rain fed rice for subsistence and commercial use. Fishing also takes place. In undisturbed areas topsoils were 20-30 thick and 8-15 cm in cultivated areas.

The adjacent uplands with slopes from 3-6% are gently undulating to undulating. The soils are well drained, shallow to deep, dark red to strong brown, gravely clay to clay. In places, the topsoil is acid humic. The soils are developed on granites and mudstones.

Soil surface crusting occurred in some cultivated fields. The crusts were 1-5mm thick and strong.

Lower Section Wetland Soils

This consists of a swamp and bottomland with slopes 0-2% and is thus flat to very gently undulating. The soils are developed on colluvial and alluvial material derived from various sedimentary and igneous rocks. The soils are very poorly to imperfectly drained, very deep, dark yellowish brown (10YR) to black (2.5Y) mottled, friable to firm, loamy sand to clay. Near the river the soils show stratification. The soils are classified as Fluvisols, Gleysols and Vertisols. Fluvisols and Gleysols occur in swamps while Vertisols occur in bottomlands. Bottomland soils are saline and/or sodic in places. The soils are sodic in places in the bottomlands. The subsoil is overlain by a 15-30 cm thick of undecomposed or partially decomposed layer.

In this section of the wetlands, it was noted that colour changed from hues of 10YR in the topsoil to hues of 2.5Y in the sub soils. During the rainy season clean water seeped from areas with thick organic matter compared to muddy water in areas that had been cleared to give way to cultivation. Erosion also occurs on cattle tracks and riverbanks where cattle are watered.

The utilization of this section of the catchments includes fishing, subsistence growing of maize bananas, millet and sugarcane, millet, sorghum, traditional vegetable, arrowroots and sweet potatoes, which mainly carried out on the edges of the wetlands.

Sand harvesting and bee keeping take place on river edges while sedge grass and reeds are used for thatching.

The adjacent uplands are gently undulating to undulating with slopes 3-7%. The soils are well drained to moderately well drained, shallow to very deep, friable, sandy clay loam to clay. The soils are developed on mainly mudstones of the Kavirondian sediments. In the uplands, growing of subsistence crops like maize and cassava dominate.

Discussion

In the upper section of River Sio catchment, soils are developed from granites, olivine basalts, nepheline, phonolites and basic tuffs or colluvial and alluvial material derived from these rocks. The predominant parent material determines the texture of the soils of the upper section wetlands. The sandy clay loam to clay range of textural class pinpoints predominance from granite to basaltic derived soils.

The topsoils form a dominant dark brown colour while the subsoil ranges from grayish brown to very dark gray. Therefore, there is a vertical increase in reduction with depth. This is shown by change of colour from hues 10YR in the topsoil to 2.5YR in the lower subsoil. The occurrence of undecomposed or partially decomposed layers is reflective of low temperatures, which favour organic matter accumulation.

The occurrence of Plinth sols in the adjacent upland areas is reflective of groundwater fluctuations leading to deposition of iron and manganese due to changing pH and redox potential. The occurrence of plinthic characteristics on the fringes of the wetlands and uplands also shows that plinthonization is progressing.

The occurrence of Ferralsols and Acrisols on the adjacent uplands and the red colours of the soils is an accumulation of iron in the soils. These red colours confirm that soil development has been taking place for a long time. Strong leaching has led to poor soils in some parts of the uplands in the upper section of the catchment.

The sodicity and salinity of the soils in some parts of this section, especially the bottomlands is due to the weathering of sodium rich feldspars which form a major constituent of the granites. The occurrence of Plano sols in these bottomlands shows a proceeding process of clay removal from the E-horizon to the B-horizon by the process of pervection. The formation of the alluvial horizon limits these soils to shallow rooted crops and pastures. In the bottomlands and some parts of the valleys where accumulation of released cations such as calcium and magnesium takes place, the cracking clay soils (Vertisols) form.

In the middle section of the catchment the soils are developed on alluvial and colluvial material derived from granites and the mudstones. The topsoils show a dominant dark brown colour whereas the subsoil is predominantly very dark gray. This shows a vertical increase in reducing soil conditions with depth. Laterally the colours change from grayish brown in the subsoil of upper section to dark gray in sub soil of middle section, which indicates increasing reduction laterally.

The lateral increase in reduction is also noted by the change of upland soils from red to dark brown in upper section to dark red to strong brown in the middle section of the catchment. The occurrence of Plinthosols alongside that of Ferralsols on adjacent uplands indicate fluctuating groundwater level and strong leaching. Silt clay texture reflects the influence of mudstones. The occurrence of soil crusts in the uplands where the soil is bare shows low aggregate stability due to low organic matter. The formation of crusts reduces rainfall infiltration into the soils thus causing erosion. Aggregate stability can be improved by use of manure or compost.

In lower section, soils are formed from alluvial and colluvial deposits derived from Kavirondo sediments and igneous rocks such as granite, basalts, phonolites and tuffs. The section consists of swamp and bottomlands. The dominant colour of the topsoil is very dark gray whereas the subsoil is dark grayish brown to black. The topsoils and subsoil show a silty clay-to-clay texture. The occurrence of stratified soils near to the river is due to periodic deposition of materials. The soils show accumulation of organic materials over the topsoil. In this section, it was noticed that siltation of the wetlands take place when the soils are opened up for cultivation as a result of organic matter being depleted due to increased oxidation. Siltation is increased when no conservation measures are taken in the adjacent uplands.

In all sections the occurrence of mottled soils is indicative of fluctuating ground water level in the imperfectly drained to poorly drained areas. In the catchment most wetland soils are poorly drained to very poorly drained. A well-covered wetland with thick vegetation all year round leads to an accumulation of a thick humic layer overlying the subsoil. The humic layer acts as a good sieve as observed by very clear water found on the topsoil at Siteko wetland code 014 (Fig. 1). The vegetation cover also contributes to the thickness of the organic matter layer in the soils as indicated at Buduluku (Sanjo) (code 015, Fig 1). This plays a significant role in sieving sediments. Whenever vegetation cover is removed in a wetland, a chain of changes occurs. This effect combined with the compaction of the topsoil by cattle along tracks may lead to a platy structure in the topsoil as observed at Munongo code 16 (Fig 1). Changes in the chemistry of topsoil also contribute to changes in the ability of wetland soils to perform their functions.

Therefore, opening up a wetland for cultivation without taking into consideration the necessary management and conservation measures, reduces the buffering capacity of the wetlands with continued use. Therefore, vegetation, clearing as observed in some parts of the lower sections (code 25) has a negative impact on the sieving and buffering capacity of a wetland.

Conclusion

Valleys and bottomlands dominate the upper part of the Sio basin while the middle section has valleys. The lower part has bottomlands and swamps. The drainage of the soils changes from imperfect to very poor in the wetlands from the upper to the lower part of the basin, respectively. The thickness of the undecomposed or partially decomposed organic matter in topsoil increases from the upper section wetlands in valleys to the lower section wetlands in swamps. The parent material dictates the dominant wetland soil characteristics and the type(s) of land use in each section of the basin.

Detailed soil assessment studies should be carried out before wetlands are put under cultivation and due consideration should be given to the necessary management and conservation measures especially in the adjacent uplands. A sustainable utilization of the wetlands should be considered in the light of the activities taking place in the adjacent uplands.

Acknowledgement

The authors acknowledge the Lake Victoria Environment Management Project for facilitating the authors to write the paper, the Head, Kenya Soil Survey and the Director, National Agricultural Research Laboratories for giving permission to present the paper.

References

FAO, (1977). *Guidelines for soil profile description*, FAO, Rome.

FAO, (1988). Nature and Management of Tropical Peat soils. *FAO Soils Bulletin No.* **59**, FAO Rome.

FAO/UNESCO., (1990). *Soil Map of the World,* Revised Legend. World Soil Resources Report **60**, FAO, Rome.

Hinga, G., F. N. Muchena, and C. M. Njihia, (1980). *Physical and Chemical methods of soil analysis.* National Agricultural Laboratories, Report No. M17, Kenya Soil Survey, Nairobi.

Munsell Colour Company, (1971). *Munsell Soil Colour Charts*, Munsell Color Co., Baltimore.

Rachilo, J.R. and D. O. Michieka, (1996). *Soils of the Busia area.* Kenya Soil Survey Reconnaissance Report No. R8.

Sombroek, W.G., H. M. H. Brown, and B. J. A. van der Pouw, (1982). *Exploratory Soil Map and Agro-climatic Zone Map of Kenya.* Report No. E1, Kenya Soil Survey, Nairobi.

Table 1: Chemical and physical characteristics of Bottomland soils (calcic Vertisols, sodic phase) in lower Sio Basin

Horizon	**Depth (cm)**	**PH-H_2O**	**EC (mmhos/cm)**	**%C**	**CEC**	**Ca**	**Mg**	**K**	**Na%**	**BS**	**ESP**	**S**	**Si**	**C**	**Si/C**	**Texture class**
Au	0-18	6.3	0.06	1.91	37.8	17.0	17.8	0.1	1.6	96	4.2	16	32	52	0.6	C
AC	18-52	7.3	0.20	0.67	34.7	24.3	22.1	0.1	2.6	84	7.5	12	20	68	0.3	C
CU	52-74	8.3	0.35	0.67	38.0	24.3	25.0	0.1	3.3	86	8.7	16	18	86	0.2	C
Cck1	74-105	8.2	0.70	0.55	34.8	16.5	24.3	0.1	3.3	96	9.5	32	12	56	0.2	C
Cck2	105-150	8.6	0.75	0.44	36.7	27.3	17.8	0.5	3.6	44	1.4	28	12	60	0.2	C

EC – Electrical conductivity; %BS – Percent base saturation; ESP – Exchangeable Sodium Percent; S – Sand; Si – Silt; C - Clay ($CaCO_3$ concretions <1%-2% 10 mm occur between 74-150 cm).

Table 2: Chemical and physical characteristics of Bottomland soils (eutric Gleysols) in lower Sio Basin

Horizon	**Depth (cm)**	**PH-H_2O**	**EC (mmhos/cm)**	**%C**	**CEC**	**Ca**	**Mg**	**K**	**Na%**	**BS**	**ESP**	**S**	**Si**	**C**	**Si/C**	**Texture class**
Au	0-30	5.5	0.06	2.40	9.0	3.2	0.8	0.05	0.68	52		56	36	8	4.5	LS
AB	30-47	5.6	0.03	0.63	4.0	1.1	0.4	Trace	0.50	50		72	20	8	2.5	SC
Bu	47-80	6.1	0.02	0.27	1.4	0.1	Trace	Nil	0.30	29		80	16	4	4.0	LS
Bgt	80-110	5.7	0.03	0.12	9.4	3.6	0.2	0.2	0.30	63		46	8	46	0.2	SC

Table 3: Some chemical and physical characteristics of valley soils (eutric Gleysols) in the middle Sio Basin

Horizon	**Depth (cm)**	**PH-H_2O**	**EC (mmhos/cm)**	**%C**	**CEC**	**Ca**	**Mg**	**K**	**Na%**	**BS**	**Sand**	**Silt**	**Clay**	**Si/C**	**Texture class**
Au	0-15	4.8	0.04	1.17	18.1	4.6	2.4	0.1	0.3	41	46	28	26	1.1	SCL
Bg_1	15-45	5.6	0.04	0.85	15.7	5.6	4.0	0.1	0.4	64	56	12	32	0.4	SCL
Bg_2	45-75	6.5	0.04	0.25	12.3	6.2	3.6	0.1	0.6	85	56	8	36	0.2	SC
Bg_3	75-120	7.4	0.20	0.44	18.9	8.7	5.2	0.1	0.5	7.8	38	8	54	0.1	C
Bg_4	120-160	7.4	0.11	0.44	21.3	12.2	9.1	0.2	0.5	100	50	10	40	0.25	SC

Table 4: Chemical and physical characteristics of valley soils (Ferralic Arenosols) in the middle Sio Basin

Horizon	**Depth (cm)**	**PH-H_2O**	**EC (mmhos/cm)**	**%C**	**CEC**	**Ca**	**Mg**	**K**	**Na**	**%BS**	**Sand**	**Silt**	**Clay**	**Si/C**	**Texture class**
Au	0-15	5.1	0.05	2.25	14.2	1.3	0.7	0.1	0.6	19	62	10	28	0.3	SCL
BU_1	15-34	5.4	0.03	1.02	5.2	1.0	0.42	0.1	0.2	33	68	20	12	1.7	SL
BU_2	34-52	5.6	0.02	0.21	3.0	0.8	0.2	Trace	0.3	43	80	14	6	2.3	LS
BU_3	52-80	5.8	0.02	0.30	1.9	0.3	0.1	Trace	0.1	26	80	12	8	1.5	LS
BU_4	80-140	5.2	0.02	0.18	7.3	1.6	0.8	0.01	0.4	38	56	6	38	0.1	SC