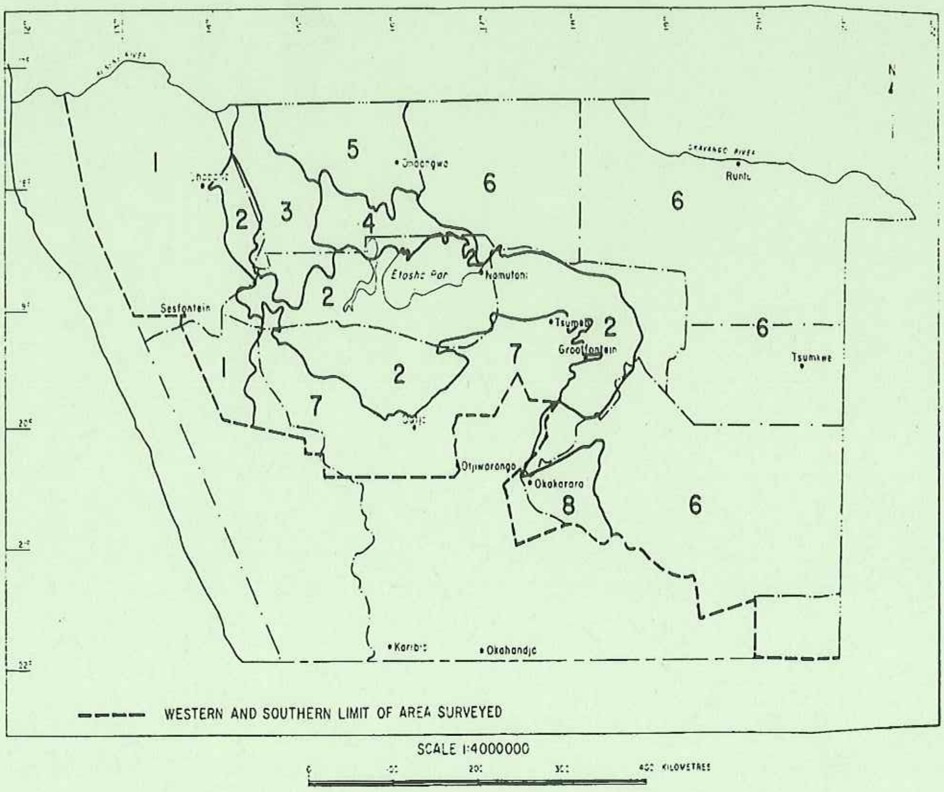
file. Literature on Soils

Soils of the regions
Omusati, Ohangwena, Oshana and Oshikoto

Compiled by Lars Møller



1. KAOKOVELD
2. KALKVELD
3. OVAMBOLAND SANDVELD
4. EKUMA GRASSLAND
5. ETAKA-CUVELAI DRAINAGE BASIN
6. KALAHARI SANDVELD
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Introduction

There is only little available knowledge about the soils of the four regions Omusati, Ohangwena, Oshana and Oshikoto. The written material available is mostly from before the liberation of Namibia and is now difficult to find, as it is scattered out in many different libraries and laboratories.

This report has been compiled from different soil surveys undertaken in former Owamboland when there were plans to irrigate parts of the region with water from the Kunene River. Some of the soil surveys are rather old, but it is my opinion, that the compiled material is not outdated.

Forest Awareness & Tree Planting Project decided to make this report in order to get a better understanding of the soils of northern part of Namibia in the regions of Omusati, Ohangwena, Oshana and Oshikoto. An understanding of the soil conditions is essential before recommending any tree species for different areas.

Lars Møller

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This report can be obtained at

Forest Awareness and Tree Planting Project
Ongwediva Teachers Resource Centre
P.O. Box 3189
Oshakati
Namibia
Telephone: **+264 (0) 6751 30057 x 17**
Fax: **+264 (0) 6751 30035**
E-mail: **forestaware@iwwn.com.na**

The Etaka Cuvelai Drainage Basin

The Etaka Cuvelai Drainage Basin constitutes a major part of the regions. The relief is monotonous and flat and the only dissection of any significance is occupied by the drainage of the oshana Etaka flowing south-east into the Etosha Pan and its north west extension, the oshana Olushandja, which flows into the Kunene River.

The land form is a vast alluvial fan or low level terrace deposited by the Kunene River in Quarternary times when the Kunene flowed into the Etosha Pan; an internal drainage system which was eventually captured via the Ruacana Falls.

The alluvia are medium textured and strongly saline and soil genesis has resulted in the formation of classic solonetz soils with an abrupt transition between the coarse to medium sand surface soils and the dense, very slowly permeable solonetz B horizon which tends to be columnar or prismatic.

A regional analyses of particle size distribution has revealed that there is a recognisable grading of the sand fraction from a coarse sand in the North to a medium and later fine sand in the South. This gradation is obviously due to fluviatile sorting of transported material apparently of granitic provenance.

In a reconnaissance slightly elevated land forms of sandy material were identified: these were the well drained sandy soils, locally derived aeolian[1] and related materials. Further field study during this current survey suggests that these higher lying materials appear to be fluviatile levees, deposited by the Kunene river and although there is good reason to believe that aeolian action has also been a contributor of soil material, the major agent of transport is probably water.

Drainage

A prominent physiographic characteristic of the regions is the lack of relief. For the greater part the drainage system is internal, terminating in the Etosha Pan, which has an elevation of approximately 1080 metres. The higher ground on the eastern, northern and western limits of the survey has a mean elevation of 1150 to 1200 metres. The four regions are thus an extremely flat and poorly drained physiographic region comprising, in the greater part, strongly saline alluvia which have been deposited by the Kunene River. To the east the alluvial plain is over taken by aeolian sands and self dunes. The western limits are confined by aeolian sands remnants, extensive deposits of Tertiary to recent calcretes from the mountainous and strongly dissected Ruacana Plateau. Where the Oshana Etaka crosses the Angola boundary minor relief exists to the extent of elevation differences of 10 metres between the floor of the Etaka valley and the surrounding alluvial plain.

[1] Soils deposited by the wind i.e. sand dunes.

Climate

The climate may be classified as semi-arid and sub-tropical with a mean annual precipitation of 517 mm., 90% of which occurs during the summer months of October to March. Summers are hot and somewhat dry with temperatures of 34 C and higher in October, the hottest month of the year. The winters are mild, July being the coolest month with a mean daily minimum of 6.2 C. The diurnal range varies between 20°C in mid-winter to about 13°C in mid-summer. The climatic data given in Table I have been recorded at Ondangwa and may be considered as being representative of the four regions.

TABLE I : CLIMATIC DATA : ONDONGUA S.W.A. WEATHER STATION
1200/866 LATITUDE 17°56'S - LONGITUDE 15°59'E - ALTITUDE 1095 m

MONTH	Air Temperatures °C MEAN DAILY Max.	Min.	$\frac{\text{MAX. + MIN.}}{2}$	Monthly Means No. of days with Temp. below 0°C	Rainfall Normals mm
January	32.4	19.2	25.5	0.0	110
February	31.2	18.8	25.0	0.0	123
March	30.7	18.4	24.6	0.0	93
April	31.0	16.7	24.1	0.0	36
May	29.1	13.0	20.3	0.0	3
June	26.3	7.2	16.7	0.1	0
July	26.5	6.2	16.4	0.3	0
August	29.4	8.3	18.8	0.1	0
September	32.9	12.8	22.9	0.0	2
October	34.4	16.3	25.3	0.0	13
November	33.3	18.0	25.7	0.0	46
December	32.0	18.7	25.3	0.0	91
YEAR	30.8	14.5	22.5	0.5	517
PERIOD IN YEARS	7	7	7	7	44

Except for the rainfall which is marginal for crop production, the climatic environment can be considered as suitable for a wide range of tropical and sub-tropical crops.

Settlement and Land Use

The main form of land use is animal husbandry; cattle, goats and donkeys are maintained. Elaborate kraals are constructed for the cultivation of millet which is the staple food. Due to the marginal and unpredictable nature of rainfall, crop failures and famine are a feature of living conditions in the regions. Periodic famine relief measures are historical in the territory. The implementation of irrigation to increase the local production of foodstuffs becomes a sine qua non in any development scheme for the regions which aims at the creation of a viable economy and a reasonable standard of living.

Vegetation

The vegetation can be broadly classified into five major associations:

- Mixed woodland of the deep aeolian sands
- The Palm Savanna
- Mopane woodland and Mopane Savanna
- Sclerocarya - Ficus Savanna
- Various scrub Mopane - Acacia

The **Mixed Woodland** of the aeolian sands occupies the entire area to the east of the main road between Namutoni and Ondangwa as well as the sand which overlies the Ruacana Plateau. The main species are *Terminalia sericea* and *Burkea africana* with *Baikiaea plurijuga, Pterocarpus angolensis*, *Ricinodendron rautanenii* and *Commiphora* spp. Except for the occasional *Pterocarpus angolensis* no exploitable timber trees occur. *Acacia erioloba* and *Combretum* spp. are encountered on the margins of the aeolian sands, normally within the termitaria zone. Nearly pure stands of *Terminalia prunioides* are also encountered on very narrow ridges of slightly heavier textured sands. On the Brown aeolian sands the communities of this association give way to *Acacia erioloba* scrub.

The **Palm Savanna** occurs in the northern central portion of the regions in the environs of Ondangwa, extending westwards to Oshakati. This area has been intensively cultivated and the palms occur in association with short secondary growth of acacia and mopane scrub. *Hyphaene petersiana* are confined to the sandier phases of the solonetz soils.

The **Sclerocarya-Ficus Savanna** occurs in the form of isolated communities within the Mopane Woodland and Mopane Savanna on non-solonetz sandy soils. This type also covers fairly extensive areas of the very deep sandy phases of the solonetz soils. All these soils are cultivated and isolated trees have been retained for the fruit supply. Besides the dominant Sclerocarya *birrea* (marula), *Adansonia digitata* (baobab) *Hyphaene petersiana* (palm), *Combretum* spp. (probably *imberbe*) also occur in this community, whilst to the south, especially on the more sandy soils, *Ricinodendron rautaneii* becomes common.

The whole of the southern central and western portions of the area carries a **Short Tree - Scrub Savanna** of various acacia and mopane - other species communities. Here the mopane is stunted and often multi-stemmed, giving the appearance of coppice growth. These poor growth forms appear to be associated with the shallow and moderately shallow soils of the Kalkveld occurring in the southern and western area bordering on the Kaokoveld. This Short Tree - Scrub Savanna, carries a very nutritious veld and should be regarded as a sweet veld.

The more or less pure stands of mopane (*Colophospermum mopane*) varying between well-grown communities of mopane woodland and the more open Mopane Savanna - are confined to the heavier phases of the solonetz soils in which the solonetz B horizon is strongly developed and fairly close to the surface. The mopane woodland is characteristic of the brown and reddish brown solonetz, whereas the grey solonetz is the soil type associated with mopane savanna. The more open vegetation is indicative of poorer surface drainage conditions and depressed topography where run-off water tends to accumulate. Indeed, well-grown tree mopane is a fairly accurate indicator of solonetz conditions. Mopane communities occupy the northern part of the four regions between Oshakati and the Ruacana Plateau.

The soils

The common parent material of the alluvial plain is a strongly saline medium textured material, amazingly uniform throughout the regions in its essential properties. This uniformity suggests a common provenance, for instance, alluvia deposited by the Kunene River in very recent times, even though the Kunene water is non-saline at the present time. The environment prevailing during the period of deposition must have been arid, a condition which would have been conducive to the accumulation and distribution of relatively unweathered and unleached materials.

The soils of the region have been classified into types according to criteria based on profile morphology and the physical and chemical constitution of the soil individuals. Typically the soil in the regions can be classified as alkali soils or solonetz.

Alkali soils occur in semi-arid areas and have at their surface a thin litter followed by a thin dark mixture of organic and mineral material and then a dark grey somewhat sandy horizon. Below this is the very distinctive middle horizon (natric B horizon, *solon*) with its marked clay increase and a pH value that is often over 8,5 due to high exchangeable sodium. These soils are unproductive owing to their alkalinity and because they are very impermeable, extremely plastic when wet and form hard clods when dry.

Genesis of alkali soils (solonetz)

Alkali soils are developed from saline soils. Saline soils are formed in hot arid or semi arid areas such as flood plains of rivers, depressions or low lying lake margins where groundwater containing salts occurs near the surface. They are characterised by accumulation of neutral salts on the surface resulting from the capillary rise of saline groundwater under conditions where evaporation exceeds precipitation, and in the absence of sufficient rain to provide regular percolation through the soil.

Alkali soils develops from saline soils low in calcium reserves when, following a fall in the water table, percolating rain water washes soluble salts down the profile and an appreciable proportion of the exchangeable calcium ions is replaced by sodium. Some of the sodium ions react with carbonate and bicarbonate anions resulting from the production of CO_2 in the soil and sufficient sodium carbonate is formed in the soil solution to raise the pH to 8,5 or above. Under waterlogged conditions sodium carbonate may also result from the reduction of sodium sulphate in the soil to sulphide which, in the absence of ions forming insoluble sulphides, is lost as hydrogen sulphide leaving the sodium ions to react with carbonate anions. The presence of an appreciable proportion of sodium in the exchange complex and of sodium carbonate in the soil solution deflocculates the clay and humus rendering the soil impermeable and giving it a grey colour. Clay particles move down the profile to form a clay pan in which some dispersed humus, washed down from above, may accumulate.

The Brown Solonetz soils

The *brown solonetz* soils and closely related types cover a vast area in the regions and it is imperative to determine their precise limitations and potentials Their essential constitutional properties are a dense and slowly permeable solonetz B horizon which is developed at a depth of about four inches below ground surface. The main limitation in this horizon is its slow permeability, even though its thickness seldom exceeds twelve inches. The underlying saline parent material occurring at a depth of about fifteen inches below the surface, is relatively little affected by soil-forming processes and is commonly fairly friable with good permeability. Its major limitation to irrigation development is its high soluble salt content. The Brown solonetz is the dominant soil along the Canal Route, but due to the severe limitations as mentioned above, it has no irrigation potential in its present state. Amelioration and reclamation are required, involving the mechanical destruction of the solon horizon, and the removal of soluble salts by leaching and drainage. Mechanical destruction presents no problem in view of the occurrence of the solon within ploughing depth. The leaching process, as a means of accomplishing permanent reclamation of the saline soil material, will be complicated by the dominance of sodium. Leaching and drainage must therefore include the addition of calcium salts to promote the replacement of sodium by calcium in the exchange complex. Usually this is achieved by adding calcium sulphate. The calcium enters the exchange complex, replacing sodium which is removed by leaching followed by natural rainfall or irrigation[2]. This treatment renders the surface layer permeable, after which rainwater or irrigation water gradually wash the gypsum down the profile so that the permeability of successive layers is gradually improved and soluble salts washed into the ground water.

Should this not be done, the sodium dominance will bring about the formation of a new solon horizon as the desalinisation process proceeds. The calcium has other beneficial effects as it improves aggregation of clay and humus and thus improves the soils structure. Calcium is also an essential element for plant growth and microbial activity.

The principal objective of a research project would be to determine ways and means of accomplishing permanent reclamation of solonetz soils. Salt tolerant crops in the first instance and other crops at a later stage could be introduced into a research programme at the opportune time, though the main objective will remain one of reclamation. Should satisfactory methods be devised, a vast area of potentially productive irrigable land could become available for crop growing. The extend of the irrigated area could however be limited by scarcity of water.

The Grey Solonetz Soils

The *grey solonetz* soils are also important soils covering large areas of somewhat depressed topography where surface run-off tends to accumulate. They differ from the brown solonetz in that this grey type has a very thick and dense solonetz B horizon, which due to its excessive thickness, cannot be destroyed by simple mechanical measures, as is the case with brown solonetz. This severe form of impermeable B horizon is the result of soil genesis in the presence of excess moisture. The grey solonetz are commonly saline at some depth but in some sites the salinity level of upper soil layers within twelve inches of the surface is low enough to permit the growth of suitable crops, such as rice. The cultivation of rice can take full advantage of the flat relief and the natural tendency for the accumulation of surface runoff. An unknown factor is the trend - either increase or decrease - of soluble salt content of the rooting zone of the rice plant as a result of irrigation. It is possible that the cultivation of paddy rice, in which excess water is applied and removed by drainage, will promote desalinisation with time though permanent reclamation of the grey solonetz is virtually impossible, due to the impermeability of deep layers. Further detailed soils surveys will be required to accomplish a more comprehensive classification of oshana soils, with particular reference to salt content of upper soil layers. There are, for instance, some oshanas of grey solonetz type soils which are severely saline even at the surface.

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[2] Calcium sulphate (gypsum) reacts with the sodium carbonate to produce calcium carbonate and soluble sodium sulphate and also replaces some of the exchangeable sodium with calcium.

Deep sandy soils

Here we refer to those locally derived, aeolian, coarse textured materials which are non-saline and non-solonetz; these are the soils which have been recommended for first and second phase irrigation and classified as the Red and Brown Sands. These types cannot be considered as ideal irrigable soils in view of limitations of excessive permeability, the very sandy textures with C contents varying between 4 and 8%, and the concomitant rather low available moisture capacities. Somewhat restrictive irrigation techniques are a limiting factor in their successful development. A further disadvantage is their pattern of distribution which comprises rather scattered, small entities. Nonetheless, with careful management, economic development is feasible, though the precise nature and productivity will have to be determined by research. Inherent irrigation management problems are a somewhat rapid infiltration rate which leads to water table problems when conventional flood irrigation methods are applied, and also a somewhat low available moisture capacity requiring fairly frequent irrigation. However, despite these limitations the productivity has been demonstrated to be relatively high under good management.

The heavy textured soils of major oshanas

Here we are particularly interested in the black expansive clays, commonly developed where a measure of through-drainage and, flooding occurs, as for instance in the Cuvelai Drainage Basin. These black clays have been observed, though little is known of their chemical properties, particularly soluble salt content. Some of these are probably non-saline and therefore suitable for irrigation development. At the time of a more detailed survey these black clay sites were under water and could not be identified and sampled. A research programme must therefore take into account the fact that some of these black clays have a potential, particularly for rice production; field investigations must be undertaken to locate these soils, determine their properties and select a site for research and investigation.

Conclusion

The soils of the region is generally poor; low in nutrients and saline. The typical soils of the area are solonetz which are formed by a combination of saline soil low in calcium and high in sodium, a cyclic period of excess water and high potential evaporation. This combined with a semi arid climate makes successful tree planting and crop growing rather difficult.

The natural plant cover is highly dependant of the type of soil underlying it which means, that by studying the vegetation, one can get a fairly good impression of the soil underlying it.

It is possible to improve the brown solonetz by mechanically braking up the hard B horizon to allow quick infiltration by water. Such mechanical treatment followed by application of gypsum, drainage and excess irrigation, can wash out a major part of the salts. Addition of Ca^{++} can exchange the Na^{+} ions of the soil, thus stabilising aggregation and improving infiltration of water and soil fertility.

Indigenous trees are adapted to the climate and the poor soils. When introducing exotics tolerance especially towards drought, salts (especially sodium), high pH and very low level of nutrients should be taken in to consideration.

The report was compiled from the following documents

An extended soil classification system for the Etosha National Park and adjacent areas in Central Northern Central Namibia. 1993. DFG/GTZ-Cooperation Project Soils and Environmental Change in the Etosha National Part/Namibia (Az: Bu 659/4-1). Field paper No. 1 - June 1993.

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Transaction of the XIII. Congress of International Society of Soil Science which was held at Hamburg 13-20 august 1986 under the patronage of the Federal Minister of Nutrition, Agriculture and Forestry, Mr. Ignaz Keichle.