MAP OF SALTY SOILS OF AFRICA

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INTRODUCTION

The map of salty soils of Africa was prepared as part of a joint project of the Subcommission on Salt-Affected Soils of the 5th Commission (morphology, genesis, and classification of soils) of the International Society of Soil Science and the Division of Natural Resources of the Department of Sciences of UNESCO to prepare saline soils maps of the continents.

As part of that project, two reports have been published: Australian Soils with Saline and Sodic Properties by K. H. Northcote and J. K. M. Skene (1972) with a map at the scale of 1 to 5 million, and Salt Affected Soils in Europe by I. Szabolcs (1974) with two maps, one at a scale of 1 to 5 million for the entire continent and the other at a scale of 1 to 500,000 for Hungary.

The draft map presented at the International Salinity Conference will be revised and published after a meeting of African soils scientists in 1977. The scale will be 1 to 5 million, the same as the draft map. In conformity with United Nations directives, Libya, Egypt, and the Sudan are included in the Near and Middle East map prepared by M. M. Elgabaly rather than in the map of Africa.

PROCEDURE

We have utilized the two 1 to 5 million soils maps of Africa prepared by J. d'Hoore (1964) and FAO/UNESCO (1975), as well as numerous maps published at that scale or at a larger scale for various African countries. Additionally, several reports and documents of the United Kingdom Land Resources Division and O.R.S.T.O.M. have been used. The assistance provided by S. A. Radwanski and G. Murdoch of the Land Resources Division and by J. Boyer and A. Mori of O.R.S.T.O.M. has been particularly helpful.

First drafts of the Africa map were presented at Subcommission meetings in Yerevan in 1969 and Cairo in 1972. A map of the savannah region was prepared for the meeting of the 4th, 5th, and 6th Commissions of the International Society of Soil Science at Tema-Accra in 1975.

Since the beginning of 1976, draft maps have been sent to the chiefs of soil services in several countries of Africa for verification of the accuracy of the delineations. Changes recommended by the reviewers have been incorporated into the present map, which represents the combined efforts of numerous colleagues.

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CARTOGRAPHIC UNITS

Cartographic units used on the map have been defined at previous meetings of the Subcommission on Salt Affected Soils. The units are:

A. Saline and Alkali Soils

1. Saline soils and solonchaks
2. Alkali soils, including solonetz and solodized soils

B. Other Cartographic Categories Shown

1. Percent distribution of salt affected soils within delineations
2. Salt affected soils of lunettes
3. Salt affected mangrove soils
4. Potentially salt affected soils

   a. Associated with presently salt affected soils
   b. Not associated with presently salt affected soils

ORIGIN OF SALT AFFECTED SOILS OF AFRICA

Soils affected by soluble salts or by their ions occupy immense areas in Africa: more than 650,000 Km^2 according to the FAO/UNESCO map, and much more according to the present map. The differences are due to the differences in definitions. Salt affected soils are especially prevalent in northern Africa, South Africa, and Botswana, and are common in the arid or semiarid zones of tropical Africa (Senegal, Mauritania, Upper Volta, Chad, northern Cameron, Swaziland, Malawi, Kenya, Zambia, Rhodesia, southern Angola, and southern Mozambique). Only Zaire, Congo, the Central African Republic, Gabon, Ivory Coast, and Liberia are virtually free of such soils.

The affected soils are very diverse in characteristics and in origin. The salts responsible for the formation of salt affected soils, as is perhaps usual in a large continent, are of marine or continental origin or are carried to the surface in artesian waters.

Salt Affected Soils Caused by Salts of Marine Origin

1. Existing Seas

It is possible that certain zones of saline soils of Africa owe their existence to tidal waters. To our knowledge, they have not however been described or mapped. If they exist, they certainly are of little extent. On the other hand, in numerous regions with alternating wet and dry periods, the sea extends far inland - sometimes more than 100 km - in the estuaries and deltas and their tributaries. Its effect is to cover the land with salty water, which persists until floods during the rainy season push some of the salty water back toward the sea. The salts gradually move through the soils and enter the ground water system. One of the typical examples of this is the pseudo-delta of Senegal. Others can be found in Madagascar, Tanzania, and Southwest Africa.

Over a large area, sea water is in contact more or less directly with the ground water of the litoral zone. In many arid and semi-arid coastal regions, and sometimes in humid areas, the process of evaporation brings saline ground water to the surface by capillary movement from shallow water tables, leading to strong soil salinization (Algeria, Morocco, Senegal, Sierra Leone, Togo, Ghana, and southern Madagascar).

In humid tropical regions, the coastal saline soils of estuaries and deltas which are rich in organic matter acquire special characteristics where the mangroves are associated with Avicennia or Rhizophora vegetation. Where such soils are drained, they become extremely acidic. They are classified as Thionic Fluvisols and have been studied in Sierra Leone, southern Senegal, the Gambia, Guinea Bissan, Guinea, Liberia, Nigeria, Cameron, Gabon, Kenya, Tanzania, Mozambique, and in western Madagascar.

Saline soils owing their origin to present-day marine influences usually are very saline (solonchaks) and have decreasing salinity with depth. They may show a weakly developed salt crust or a horizon of pseudo-sand (very fine aggregate of saline-alkali clay) on the surface. In more humid regions, salinity may increase with depth, but this is relatively rare.

2. Extinct Seas

Soils affected by salts deposited from former seas during the Quaternary period are widespread in Africa. Saline parent material has given rise to saline soils wherever the climate is favorable for salt accumulation. This is the case in the lower valley of the Chelif River in Algeria, in the pseudo-delta and the valley of the Senegal River, in Southwest Africa, and in numerous other countries.

Moreover, some gulfs have become filled, little by little over the last 3,000 to 4,000, by the alluvial and colluvial deposits. The sea water thus trapped gives rise to saline lakes and, finally, to saline ground water which often is close to the soil surface, such as in the lower valley of the Medjerda River in Tunisia. As before, the dominant ions are chloride, sulfate, and sodium.

3. Transported Marine Salts

Transported marine salts constitute another source of soil salinity in certain parts of Africa. In several cases, the principal salt deposited as the result of leaching of ancient marine rocks is gypsum; others include sodium and magnesium sulfate and chlorides. Rocks of Triassic and Miocene age in northern Africa and Triassic or Permian in Rhodesia and South Africa are important sources of soluble salts and gypsum.

While ancient rocks may be covered with saline soils, their more significant effect on salinity is felt in depressions or in lower parts of valley systems into which runoff water drains. Salts brought to the surface by evaporation during dry periods are deposited and accumulate at lower levels when floods sweep across the drainageways.

Utilization of saline ground water from these geologic materials for irrigation is another source of salt affected soils when drainage is poor and the climate is arid. Even when the rainfall is as much as 1,000 mm, low lying impermeable soils may be saline if annual evaporation is high, as it commonly is in tropical Africa. Transported marine salts are often the source of soil salts in Morocco, Algeria, Tunisia, northern Nigeria, Swaziland, Botswana, and South Africa.

Accumulation of soluble salts can be the result of a pedogenetic process involving seepage of rain water. Salts have been shown to accumulate beneath calcrete horizons in Morocco and Algeria. Breaking up or removal of calcrete to permit cultivation of land risks the possibility that the underlying salts will then rise to the soil surface.

Commonly, the soils affected by transported marine salts are solonchaks with a cation exchange complex dominated by calcium and magnesium or by sodium. There sometimes is a more or less thick salt crust or a pseudo-sand horizon of five to six centimeters in thickness on the surface. That is the case in Algeria, Southwest Africa, and South Africa. Alkali soils having a similar origin occur in Morocco, Algeria, and northern Nigeria. Solonetz soils have been noted in Botswana where rainfall is greater.

The soil salts generally are largely chlorides but sulfates often are of great local importance, as in the formation of gypsiferous soils. The dominant cation normally is sodium but it may be the calcium-magnesium combination. Hydroscopic soils composed principally of calcium and magnesium chlorides have been observed in the Hauts Plateaux of Algeria, where they are weakly alkaline, and in the Sabi Valley of Rhodesia, where they are acidic.

In zones where the salt affected soils have a marine salt origin, their extension, whether natural or due to irrigation or other management practices, is growing. The spread of salt affected soils is gradually outward from a source or is of a spotly nature.

Salt Affected Soils Caused by Salts of Continental Origin

Weathering of rocks containing sodium minerals (feldspars, amphiboles, etc.) produces soluble sodium salts, principally carbonates and bicarbonates, often sulfates, sometimes silicates, and rarely chlorides. Such rocks are numerous and often of great extent in Africa. Under certain conditions

of climate and topography, their weathering products may accumulate and lead to the formation of saline or sodic soils.

In arid regions, closed basins such as Lake Chad are practically always saline due to the salts brought in by streams draining into the basins. The principal salt affected soils are solonchaks, frequently with salt crusts on the surface or strongly saline horizons at shallow depths, as in Chad, Kenya, Botswana, and Mali, among others. Many of the salt crusts containing concentrated sodium carbonate or sodium chloride are exploited commercially. In marshy areas where the soils are rich in organic matter, as in certain branches of Lake Chad, a variety of salt affected soils may be formed (Cheverry, 1974).

In subhumid regions and in certain semiarid regions where excess water accumulates, the situation is different. Here, the dissolved sodium accumulates as exchangeable sodium in the B horizon, due to vertical or horizontal leaching. The soils which result are solonetz, solodized soils, or solodized planosols. Formation of these solodized soils is favored by hydromorphic conditions and high soil temperature. They are found in Upper Volta, northern Togo, northern Nigeria, northern Cameroon, Chad, Malawi, Botswana, Rhodesia, Swaziland, Lesotho, and other tropical countries. Solonetz and solodized soils are very susceptible to water erosion. They are generally associated with higher lying Leached Tropical Ferruginous Soils (Chromic or Ferralitic Luvisols),which often are hydromorphic, and lower lying vertisols (Bocquier, 1971).

Numerous vertisols have a B horizon with a very high exchangeable sodium percentage and possess the physical properties of alkali soils. They occur in Tunisia, Kenya, Tanzania, Uganda, Zambia, Lesotho, Swaziland, and South Africa and have been classified as alkali soils.

Salt Affected Soils Caused by Saline Artesian Waters

Salts in artesian waters originate either from saline sediments or by alteration of native rocks. Most of the waters are moderately or slightly saline; they become concentrated by evaporation in soil strata at or near the surface. The chotts of Algeria and Tunisia (Belkhodja, 1972). are examples of vast areas where salt crusts have formed as the result of artesian waters rising to the surface.

Salt affected soils of Africa are quite variable in their characteristics and origin. Some of them are unlikely to increase in area, others are likely to do so. Salinization is a threat in many places where salinity is not presently a problem, which makes it important to study the process of salinization and to maintain continued surveillance of susceptible areas. The FAO/United Nations Environment Program on soil degradation and desertification, with the collaboration of Unesco and other national and international organizations, can be the source of very valuable information on soils and land management throughout the world. It needs continued support.

SUMMARY

A draft map of the distribution of salt-affected soils of Africa has been prepared on behalf of the subcommission on Salt-Affected Soils of the ISSS. A final draft is to be prepared in the near future. Causes of salt accumulation in African soils were discussed and a bibliography of pertinent references was presented.

SELECTED BIBLIOGRAPHY

Published and unpublished reports on saline and sodic soils of Africa are so numerous that it is impossible to give an exhaustive list. The publications listed here are principally those utilizted in preparation of the latest map of salt affected soils. A large number of unpublished reports has also been used.

Belkhodja, K. 1972. Origine et caractéres de la salinité dans les sols de la plaine de Kairouan (Tunisie centrale), Sols de Tunisie, D.R.E.S. Tunis, 4, 105 p.

Bocquier, G. 1971. Génese et évolution de deux toposéquences de sols tropicaux du Tchad - O.R.S.T.O.M., Bondy, France, 351 p.

Brammer, .. 1971, 1973. Soils of Zambia, Division of Overseas Surveys, Tolwo .., Surrey, England.

Brunt M. 1960. The land use map of Gambia, Division of Overseas Surveys, Tolworth, Surrey, Engl.. d.

Cheverry, C. 1974. Contribution á l'étude pédologique des polders du Lac Tchad, O.R.S.T.C.M., Bondy, France, 280 p.

da Costa, J. Botelho. 1963. Soils of Angola, J.T.V., Lisbon, Portugal.

FAO-UNESCO (J. Ricquier), 1975. Carte des sols du monde, Afrique, 3 feuilles, UNESCO, Paris, France.

Jordan, H.D. 1964. The relation of vegetation and soil development of mangrove in Sierra Leone, J. Appl. Ecol. 1:209-212.

Hervieu, J. 1968. Contribution a l'étude de l'alluvionnement en milieu tropical: les facteurs de la sédimentation continentale; les produits de érosion, les sols alluviaux sur le versant occidental de Madagascar. Mémoire O.R.S.T.O.M., Bondy, France, n° 24, 465 p.

d'Hoore, J. 1964. La carte des sols d'Afrique, Commission de Collaboration Technique en Afrique, Lagos, 93, 210 p.

Maignien, R. 1965. Carte des sols du Niger (1/1,000,000), Cartes et Notices O.R.S.T.O.M., Bondy, France, n° 24.

Mitchell, A. 1967. A reconnaissance assessment of the irrigation potential of soils along the main rivers of Eastern Bechuanaland. Division of Overseas Surveys, Tolworth, Surrey, England.

Murdoch, G. 1970. Distribution of saline and alkali soils in some Africa countries. 2nd Approximation. M.R. 80, Division of Overseas Surveys, Tolworth, Surrey, England.

Northcote, K.H., and J.K.M. Skene. 1972. Australian soils with saline and sodic properties. C.S.I.R.O.S., Melbourne, Australia, Soil Publication No. 27, 62 p.

O.R.S.T.O.M. 1976. **Carte pédologique des sols du Benin (1/200,000),** O.R.S.T.O.M., Bondy, France.

Radwanski, S.A. 1969. Distribution of saline and alkali soils of some African countries, 1st-Approximation, Division of Overseas Surveys, Tolworth, Surrey, England. M.R. 67, 100 p.

Riquier, J. 1967. Carte pédologique de Madagascar (1/1,000,000), O.R.S.T.O.M., Bondy, France.

Scott, R.M. 1961. Soil map of East Africa, East Africa Literature Bureau, Nairobi, Kenya.

Szabolcs, I. 1974. Salt affected soils in Europe, Research Institute for Soil Science and Agricultural Chemistry, Budapest , Hungary, 63 p.

Thompson, J. 1965. The soils of Rhodesia and their classification. Department of Research and Special Service, Salisbury, Rhodesia, Tech. Bull. 6.

Tomlinson, T.E. 1957. Changes in a sulphide containing mangrove soil. Emp. J. Exp. Agr. 25:108-118.

Vieillefon, J. 1974. Contribution a l'étude de la pédogénèse dans la domaine fluvio-marin en climat tropical d'Afrique de l'ouest. O.R.S.T.O.M., Bondy, France. 410 p.

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