CHAPTER : I

DEVELOPMENT OF SALINE AND ALKALI SOILS : STUDIES OF SALINE AND ALKALI SOILS IN INDIA
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Classification of soils have been attempted on various lines. The problem is perhaps more complicated than the problem involved in the classification of elements or plants. According to American (United State Department of Agriculture) system of classification soils are first divided into three great groups:

(a) Zonal groups are primarily influenced by climate in which they have developed.

(b) In the intrazonal groups, drainage also contributes to the nature of the soil.

(c) Azonal soils are without profile characteristics.

These groups have again been redivided into various subdivisions. The saline and alkali soils belong to the Intrazonal group. Studies of such soils have been pursued for over eighty years.

The fact that alkali begins to appear (usually in localised spots) within a few years after irrigation is introduced in a given area has been observed in many parts on the semi-arid regions of the world(33).
Although irrigation is useful and practised in various areas of heavy precipitation, it becomes an indispensable requirement in what is known as arid zones. The aridity of a region depends upon temperature as well as precipitation. Thornthwaite (77) formulated the effectiveness of rain in terms of mean monthly temperatures. As defined by him, the effectiveness varies directly with precipitation and inversely with temperature. Many alternative methods of defining aridity have been suggested by different workers, all of which involve temperature and precipitation. Where rainfall is less than 10 inches, desert conditions may prevail (16). In arid regions evaporation exceeds precipitation, resulting in accumulation of soluble salts. Soluble salts may also accumulate at those places where inland seas or arms of the oceans have evaporated (38). In such soils, the ground water is sufficiently near the surface to permit the rise of capillarity of water together with the dissolved salts into the top layers where evaporation takes place. Salts need not always accumulate where they originate due to weathering of rocks. If water from one area drains to another area which is usually a shallow basin, salts may accumulate. In fact, this appears to be the case in most of the places. There is a third possibility of accumulation
of salt in any area. The presence of sodium chloride particles in the precipitation may result in the accumulation of salts in the region (19). L. J. H. Teakle (75) estimates that the annual contribution of cyclic salts in Western Australia may account to as much as 300 pounds per acre. According to Holland and Cristle (28) the huge salt beds in the Rajputana desert are due to the wind borne sand, carrying salt particles.

All soils of the dry climate are not necessarily affected by alkali. The first requirement for the occurrence of saline and alkali soil is the accumulation of soluble salts (9). An additional essential factor for the development of saline and alkali soils is the existence of impervious structure in the sub-soil, which prevents the penetration of water underground and results in high ground water levels.

Saline and alkali soils occur in arid regions. About one fourth the area of the world is classified as arid zone, while one third is classified as semi-arid zone (76). Thus more than half the land of the world falls under these two categories. A higher percentage of the alkali soils in the world is alluvial in nature. Most of these soils could be reclaimed under artificial irrigation. Artificial irrigation is both a friend as well as a potential enemy. In the absence of adequate drainage,
artificial irrigation may raise the ground water level and may render otherwise fertile soils into unproductive soils. Thus the utilisation of land requires careful consideration of irrigation, and what is more important, of an adequate and a suitable system of drainage. Neglecting the latter factor, results in the spread of alkali soils. In certain of the old irrigated countries, the spread of alkali has assumed alarming proportions. In India, Pakistan, and Egypt, the spread of alkali has been over large areas of productive soils. It is estimated that 30,000 acres of land are going out of use every year in the Punjab area of Pakistan(28). Mackie(37) records that in 1873 the water table at Fresno in the San Joaquin Valley was 65' deep and the soils were practically free from salts. As a result of irrigation without adequate underground drainage, in eleven years the water table has risen as much as 2 to 3' below the surface and the soil was rendered definitely alkaline. Certain authorities(38) question the use of irrigation as a potential factor for agriculture. This view is rather pessimistic and a wise, careful and controlled programme of irrigation is essential for many places, where not only rainfall is scanty but fluctuates widely from year to year. In fact, for areas with low rainfall, irrigation is the only answer and in its absence large tracts of land will have to be
abandoned for good. On the other hand, absence of scientific control of irrigation may result in water logging and accumulation of salts in otherwise fertile land.

Saline and alkali soils are in a state of dynamic equilibrium. With the ever changing factor of rainfall and temperature, combined with an unwise approach to the utilisation of land, such soils undergo continuous changes. The broad aspects of these changes have been well understood.

Studies of saline and alkali soils have been pursued for over eighty years. In 1892 Hilgard(26) published a report on the relation between soil and climate in which he discussed studies on alkali soils started by him in 1888. Vilenski(83) and de Sigmoid(69) cite references to alkali soils dating back to the 18th century. Hilgard divided the alkali soils into two groups, white alkali and black alkali soils, the former containing sulphate and chloride of sodium and sometimes of magnesium; and the latter containing carbonate of sodium. In 1912 Gedroiz (23) presented his view on the genesis of the soils based upon the phenomena of exchangeable cations.

Saline and alkali soils have been extensively studied by workers of the U.S. Salinity Laboratory(80), Kelley(32,33), Kovda(34,35), Darab(20), Antipovkarataev
and Kader(5), Szaboles(74), Elgably(22), Varallyay(81,82) and others. In India pioneering work has been done by the scientists of the Central Soil Salinity Laboratory at Karnal. The early work was started by Dhumbia(10,11,12,13,14,15), Yadav(84,85,86,87,88,89,90), Abrol(1,2,3,4), Kanwar(31). In addition to this, Basu(8) made critical study of saline soils in Maharashtra. Raychaudhary has made a systematic study about classification and management of saline soils in India(54,55). Saline-alkali soils in Gujarat have been critically studied by Trivedi, Shah and co-workers(64,65,66,67,68,78,79). Some other workers in the field who have made significant contributions are Nithur and co-workers(39,40), Mehta and co-workers(41,42,43,44,45,46), Panamoororthy and co-workers(51,52,53), Sheth and co-workers(60,61,62), Singh and co-workers(71,72,73) and Dixit and co-workers(21). In fact the Panjab irrigation authorities laid down a foundation for studies in Saline-Alkali Soils in India before 50 years.

According to Russian workers(30) the alkalization of soil takes place in the following three stages. The first stage consists of the process of salinization i.e. the accumulation of soluble salts at the surface. Such soils are called SOLONCHAK. The second stage consists of desalination, whereby the soluble salts are removed and the complex becomes progressively saturated with sodium.
Such soils are known as SOLONETZ. In the third stage, soluble salts are completely removed and due to hydrolysis the silicates are released. Such soils are known as SOLODI.

The above system of division is broadly followed by Sigmond (70), who describes the various stages as follows:

1. SALT IN SOILS: The first stage consists of accumulation of sodium salts.

2. SALTY ALKALI SOILS: In the second stage of alkali soil formation, the nature of the absorbing complex is changed by the sodium salts.

3. LEACHED ALKALI SOILS: The third stage of alkalinization is due to the intensive leaching of the salts, when the soil becomes of the solonetz type.

4. DEGRADED ALKALI SOILS: The leaching of soluble salts is followed by the hydrolysis of the sodium complex. This results in sodium being replaced by hydrogen and the soil reaction becomes acidic.

5. REGRADED ALKALI SOILS: If owing to some reason, water level rises up again, the degraded alkali soils become regraded and the soils become saline again.
According to U.S. Salinity Laboratory (80), saline and alkali soils are divided as follows:


(1) SALINE SOIL: A non-alkali soil containing soluble salts in such quantities that they interfere with the growth of most crop plants. The electrical conductivity of the saturation extract is greater than 4 microsiemens per centimeter at 25°C and the exchangeable sodium percentage is less than 15. The pH reading of the saturated extract is less than 8.5.

(2) SALINE ALKALI SOIL: Such soils contain sufficient exchangeable sodium to interfere with the growth of most crop plants and contain appreciable quantities of soluble salts. The exchangeable sodium percentage is greater than 15, and the electrical conductivity of the saturation extract is greater than 4 microsiemens per centimeter at 25°C. The pH readings of the saturation extract are usually less than 8.5.

(3) NON-SALINE ALKALI SOIL: Such soils contain sufficient exchangeable sodium to interfere with the growth of most crop plants and does not contain appreciable quantities of soluble salts. The exchangeable sodium percentage is
greater than 15 and the electrical conductivity of the saturation extract is less than 4 mho per centimeter at 25°C. The pH reading of the saturated soil paste is usually greater than 8.5.

According to Chapman (18) maritime salt-marshes and inland salt deserts carry a similar or almost identical vegetation. Morss (45) has critically reviewed all the factors leading to the formation of various types of saline and alkali soils, taking into consideration the geographical situation, the climatic, topographic and hydrologic factors as well as local vegetation. The various factors enunciated by him are as follows:

(a) Temperature: This exerts a much more profound effect in places where the ground is not regularly submerged. In central continental regions, high summer temperatures are of great significance.

(b) Rainfall: This will be responsible for downward leaching of salt in the upper layers of the soil.

(c) The height of the marsh in relation to sea level:

Lower marshes are flooded more frequently than upper marshes, but in the former, the continuous influx of the sea will maintain a more or less steady saline content, whilst in the case of higher marshes the long periods of
continuous (nontidal) exposure, especially in summer will result in evaporation and an increased salt concentration.

(d) Nature of the soil: A marsh built of a fine silty mud is likely to retain more salt than one having a high proportion of sand.

(e) The presence or absence of vegetation: The presence of plants brings about a rise in the soil water and reduce the rate of evaporation from soil surface. Bare soil always attains a higher salt concentration in summer than the vegetation covered marsh.

(f) Inclination of the ground: The greater the slope, the more rapidly the salt water drains off.

(g) Depth of soil water table: The nearer the water table is to the surface, the more constant will be the soil salinity.

In the case of inland saline soils, factors (d), (b), (e), (f), and (g) will be operative, while the following additional factors will also have to be considered for coastal marshes:

(h) Depth of sub-surface salt deposits: The greater the depth, the less saline will be the surface layers.

(i) Inflow of streams into the area: The streams may bring salt with them or they may dilute the salt water already in the basin.
A MAP OF INDIA SHOWING THE AREA UNDER STUDY
The State of Gujarat, a part of the old Bombay State (up to 1960), is situated on the West Coast of India between 20°1' - 24°7' N and 68°7' - 70°4' E (see map on opposite page). To the West of Gujarat is the Arabian sea, Maharashtra is to the south. On the eastern side, there are mountain ranges and forests of Madhya Pradesh. In the north-east and north-west there are arid regions of Rajasthan and Pakistan respectively.

The rainfall in N-Gujarat is low, varying between 20" to 40". It gradually increases as one proceeds southwards, and it is about 50" to 60" around Surat. The precipitation is confined to only a few days from June to September. There is a wide variation in the annual precipitation. Every third year is a year of drought. The temperatures are somewhat lower in the southern districts and higher in northern districts. The maximum daily temperature for summer months vary between 98° to 116°F. The winter temperatures vary from 30° to 67°F.

The most important river of Gujarat is the river Narmada, which flows through the Broach district. The second important river is Tapti, near Surat. Sabarmati, Mahi, Banas and Bhogavo are some of the other prominent rivers of Gujarat.
According to an estimate by Central Soil Salinity Research Institute, Kernal, there are one-crore acres of salt-affected soils in the whole of India, out of which twenty - lac acres are located in Gujarat. In Gujarat salinity problem has originated from many sides. For example, the arid and semiarid regions of Kutch and N. Gujarat are salty because of the existence of old sea in the area. The land of Dhal Pradesh and Nal-Kamtha is a saline land due to sea-water inundation, as it is the land which is a connecting link between the Gulf of Kutch and the Gulf of Cambay. Lacs of acres of land adjoining sea-coast is saline, due to sea-inundation. Many thousand acres of land in canal-irrigation areas have been rendered saline due to unwise use of water without providing drainage. In addition, the oil-exploration in areas like Cambay, Ankleshwar, Sanand, Naksana, Dholka, Kalol, Navagam has brought out the oil-field waters, which are prominent in sodium-bicarbonate content which turns an area saline-alkali within 5-6 years usage of irrigation water of tube-wells (200'-600').
REFERENCES


83. Vilenski, D.C., Rep. 1, Intern. Congr. Soil Scientists in Washington, 1927, p. 120.


