CHAPTER I

INTRODUCTION:

DEVELOPMENT OF SALINE AND ALKALI SOILS
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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, or animals. According to American (United States Department of Agriculture) System of classification (36), Soils are first divided into three great groups.

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

(b) In the interzonal groups, drainage 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 interzonal group. Studies of such soils have been pursued for over eighty years.

According to Russian workers (29), the alkalization of soil takes place in the following three stages;
the first stage consists of process of salinization, i.e. the accumulation of soluble salts at the surface, such soils are called SOLONCHAK. The second stage consists of desalinization, whereby the soluble salts are removed and the complex becomes progressively saturated with sodium ion. Such soils are called SOLONETZ. In the third stage, soluble salts are completely removed and due to hydrolysis the Silicates are split and $\text{SiO}_2$ is released. Such soils are called SOLODI.

The above system is broadly followed by Sigmund(65) who describes the various stages as follows:

(i) Saline soils: The first stage consist of accumulation of sodium salts.

(ii) Salty-alkali soils: In the second stage of alkali soil formation, the nature of absorbing complex is changed by the sodium salts.

(iii) Leached-alkali soils: The third stage of alkalinization is due to the intensive leaching of salts when the soil becomes of solonetz type.

(iv) Degraded-alkali soils: The leaching of soluble salts is followed by the hydrolysis of sodium complex. This results in sodium being replaced by hydrogen and the soil reactions becomes acidic.
Regraded-alkali soils: If owing to some reasons water level rises up again, the degraded alkali soils become regraded and the soils become saline again.

According to U.S. Salinity Laboratory (76), saline and alkali soils are divided as follows:

<table>
<thead>
<tr>
<th>Type of Soil</th>
<th>EC of Satu (in mhos/cm)</th>
<th>pH of Satu</th>
<th>ESP</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline soil</td>
<td>&gt; 4</td>
<td>&lt; 8.5</td>
<td>&lt; 15</td>
<td>These soils contain soluble salts in such quantities that, they interfere with the growth of crop plants.</td>
</tr>
<tr>
<td>Saline alkali soil</td>
<td>&gt; 4</td>
<td>&lt; 8.5</td>
<td>&gt; 15</td>
<td>These soils contain appreciable quantity of soluble salts and sufficient exchangeable sodium to interfere with the growth of crop plants.</td>
</tr>
<tr>
<td>Non-Saline alkali soil</td>
<td>&lt; 4</td>
<td>&gt; 8.5</td>
<td>&gt; 15</td>
<td>These soils do not contain appreciable quantity of soluble salts, but contain sufficient exchangeable sodium to interfere with the growth of crop plants.</td>
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Morse (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, climatic, topographic, and hydrologic factors as well as local vegetation. The diverse factors enunciated by him are as follows:

(a) Temperature: This exerts a profound effect in places where the ground is not regularly submerged. In central continental regions, a high summer temperature 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, a continuous influx of the sea will maintain a steady saline content, whilst in higher marshes the long periods of continuous (non-tidal) exposure, specially in summer, result in evaporation and an increased salt concentration.

(d) Nature of the soil: A marsh built of a fine silty mud retain more salt than one having a high proportion of sand.
(e) The presence or absence of vegetation: The presence of plant brings about a rise in the soil water and reduces 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 the soil water table: High water table is responsible for more salinity of soil.

In case of inland saline soils factors (a), (b), (e), (f) and (g) operate 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 bring salt with them or they may dilute the salt water already in the basin.

Alkali begins to appear within a few years after irrigation is introduced in a given area and this fact has been observed in many parts on semi-arid regions of the world (32).
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 (72) 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, but all involved temperature and precipitation, where rainfall is less than 10 inches, desert conditions prevail (16).

Saline and alkali soils occur in arid regions. About one fourth area of the world is classified as arid zone, while one third as semi-arid zone (71). Thus, more than half of the land of the world falls under these two categories. The main cause of the formation and occurrence of salt affected soils is the accumulation of sodium ion in the solid and/or liquid phase of the soils. Water plays a decisive role as a reactant, solvent and transporting agent in salinization and alkalinization processes.
According to FAO/UNESCO (23), under arid or semi-arid conditions, and in regions of poor natural drainage, there exists potential possibilities and a real hazard of sodium salt accumulation in soils from the saline or brackish irrigation water, or from the shallow saline ground water. The main reason for the formation of saline soils is the upward and downward movement of soil solution and salts get distributed and/or accumulated either in the surface layers, or in the sub soil, and during dry period, the surface of the soil is covered with salt crust.

Leather (34) summarised the origin of salts in soils of North India in the following four ways.

(a) From the sub soil bed salts for which no possible evidence existed.
(b) Brought down by the rivers, obtained from rock dissolution, and deposition along with the alluvium.
(c) From the soil itself by further decomposition of soil mineral and
(d) From the canal water.

Richard (46) explained that when excess soluble salts accumulate in the soil, sodium frequently becomes
dominant cation in the soil solution and thereby results in alkali soils. Howard (25) reported that anaerobic bacteria, bringing about a reductive phase in the soil, are the real agents, which give rise to a harmful salts which occur in alkali tract. These bacteria are also responsible for conversion of fresh water into salty lakes. Sokolovsky (54) studied the rock weathering and considered that the primary source of all kinds of salts in soils to be due to weathering.

All soils of the dry climate are not nearly affected by alkali. The first requirement for the occurrence of saline and alkali soils is the accumulation of soluble salts (9). An additional essential for the development of saline alkali soils is the existence of impervious structure in subsoil, which prevents the penetration of water under ground and results in high ground water level. Agrawal et al (6), reported that a combination of factors such as geological climatic and hydrologic are involved in the formation of saline and alkali soils.

As early as 1892, Hilgard (28) published a report on the relation between soil and climate, in which he discussed studies on alkali soils started by him in 1888.
Vilenski (79), and desmond (64) 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 magnesium, and the latter containing carbonate of sodium. In 1912 Gedroiz (24) presented his views on the genesis of the soils based upon the phenomena of exchangeable cations.

From time to time different workers have reported the accumulation of salts in soil. Raychaudhari et al (52), pointed out that the accumulation of soluble salts at the surface was high due to capillary rise of water and its evaporation from the surface. Razumoy (53) stated that raising the level of ground water, above an average depth of 3 meters, may cause secondary salinization and impair the physico chemical properties of the soil. Chaudhari and Khepar (17) found in Punjab soils that salt accumulation depends on texture, watertable and salt concentration of ground water. Dhir et al (18), summarised that the salinity is high to very high and ranges from exclusively Na-Cl type to Na-Ca-Cl-SO₄ type. Distribution of salt affected lands of Pali block, Western Rajasthan, appears to be related to down
slopes nature of the site and poor surface drainage.

A high percentage of alkali soils in the world is alluvial. 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 the otherwise fertile soils unproductive. Thus the utilisation of land requires careful consideration of irrigation, and what is more important of an adequate and suitable system of drainage. Neglecting the later factor results in the spread of the alkali soils.

Bhadrapur and Seshagirirao (7) reported that in a number of locations in the Tungabhadra project area in Karnataka, the lower land soils were affected by salinity and alkalinity due to seepage from uplands. Thus reclama­tion programme can be taken after a thorough geo-chemical classification of soil and water in the area.

Saline and alkali soils have been extensively studied by workers of the U.S. salinity laboratory (76), Kelley (31, 32), Kovda (33, 34), Darab (19), Antipov—karataev.
and Kadar (5), Szabolos (69), Elgably (21), Varallyay (77, 78) 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 Bhumbla (10, 11, 12, 13, 14, 15), Yadav (80, 81, 82, 83, 84, 85, 86), Abrol (1, 2, 3, 4) and Kanwar (29). In addition Basu (8) made critical study of saline soils in Maharashtra. Ruychandhary (50, 51) has made a systematic study about classification and management of saline soils in India (50). Mathur and coworkers (37, 38), Mehrotra and coworker (39, 40, 41, 42, 43, 44), Ramamoorthy and coworkers (47, 48, 49), Sheth and coworkers (55, 56, 57), Singh and coworkers (66, 67, 68), and Dixit and coworkers (20) have made significant contributions towards the study of saline alkali soils. The Punjab irrigation authorities laid down a foundation for studies in saline alkali soils in India before 50 years. Saline alkali soils in Gujarat State have been critically studied by Shah and coworkers (59, 60, 61, 62, 63), and Trivedi et al (72, 73).

According to an estimate by central soil salinity research laboratory Karnal, there are one crore acres of salt affected soils in the whole of India, out of which
thirty lac acres are located in Gujarat State. In Gujarat, salinity problems has originated from many sides. The arid and semi arid regions of Kutch and N-Gujarat are salty because of the existence of old sea in the area. The land of Sindh Pradesh and Mal-Kantha is a saline land due to sea water inundation, as it is the land which is a connecting link between the Guld of Kutch and Guld 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 oil water without providing drainage. In addition, the oil exploration in areas like Cambay, Ankleshwar, Sanand, Mehsana, Dholka, Kalol, Navagam has brought out the oil field waters, which are prominent in sodium carbonate content, which turns an area saline alkali within 5-6 years usage of irrigation water of tubewells (depth 200' - 600').

Hollant and Christie (27), Teakle (7), Erik Eriksson (22) concluded that one of the important factors responsible for further spread of salinity in non saline region is the wind borne salt particles from adjoining sea shores or salty deserts. This conclusion supports increasing salinity of the soil of Kutch because salt particles,
carried by wind deposited on fertile agricultural soil and renders the soil unfit for cultivation.

Some of the important sources contributing towards salinity in arid and semi-arid tracts of Gujarat State are as follows:

(i) Salinity develops in the area of Kutch and North Gujarat, where evaporation exceeds precipitation.

(ii) Small rivers disappear in the region as they are accumulating salt.

(iii) The high water table in Bhachau taluka, and in parts of little Rann of Kutch, augment the salts in the surface soils.

(iv) One of the principal factors is that the whole area remained under sea at one time, and sudden rising of the land looked large quantities of sea water under ground. A high Cl/NaCO₃ index suggests intrusion of sea water under ground. The occurrence of large quantities of gypsum is a direct proof of the existence of sea in the region.
Trivedi and Shah (75), Shah (58), reported the existence of brine well water near 'Kharaghoda' and various salt pans in little Rann of Kutch, which supports the above hypothesis.
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