SUMMARY

The present work has been divided into seven chapters.

In chapter I an attempt has been made to review literature on classification of soils with special reference to saline-alkali soils. The study on saline-alkali soils started as early as 1892 and was begun by Hilgard. Notable contributions have been made by De Sigmond in Hungary, Kelley in America and Gedroiz in Russia. The systematic study of saline-alkali soils all over the world became much more prevalent after the U.S. Salinity Laboratory published the Handbook No. 60.

In India, an early study was started by Basu in Maharashtra. A systematic study of saline-alkali soils in India was started by Bhumbla, Yadev, Abrol and coworkers at the Central Soil Salinity Laboratory Karnal. At Gujarat University work on saline soils was started at M.G. Science Institute by Dr. A.M. Trivedi and his students.

In the present work the area of North Gujarat has been selected for the study because of its peculiar semi-arid climate. Rainfall in North Gujarat is low, varying between 20" to 40" and drought years recur frequently. The maximum daily temperatures for summer months vary between 98°F to 116°F. The western part of North Gujarat has its boundary ending in the Little Rann of Kutch which is a salty barren track.
In chapter II the problem of salinity of soils and waters of North Gujarat has been discussed critically. The geology and origin of the Rann of Kutch has been reviewed. Evidence is available which gives information that an eastern branch of river Indus flowed through the present great Rann of Kutch into the Arabian sea and that portion of the Rann were highways of commerce from Kutch to Sind and from Kutch to Rajasthan. The Rann has been raised above the bed of the sea by the long continued debris from highlands of Kathiawar and Kutch and the silt and sand from Rajasthan and Sind.

The great salt waste covering an area of about 8000 sq. miles forms the Rann of Kutch and is located between 20° 47' to 24° N and 65° 26' to 71° 10' E. This is an entirely barren track. Thus, average annual rainfall in Little Rann is 15" and in the Greater Rann it is 10".

Some evidence regarding the existence of sea water and its land locking are available from geological, geochemical and oil exploration studies.

In such an arid region, before 15 years a co-operative Dairy movement was started. To-day the Duchsagar Dairy located at Mehsana collects about 5 lac kgs. of milk every day. This is a Co-operative Dairy.

In chapter III different methods followed for analysis of soil and water have been described. Location and description of soil and water samples has been given.
In chapter IV an assessment of irrigation water quality has been presented. In arid region the rivers Banas, Luni and Sarswati flow, but these are not perennial rivers. However, for the last thirty years people have taken up an activity of obtaining water by digging tube-wells of depth 200' to 1000'. There are about 3600 tube-wells in North Gujarat. The underground waters are salty and on continuous irrigation makes the soil sodiumised. Thus the tube-well waters have made the problem of saline-alkali soils more acute and widespread in North Gujarat.

The ground waters in Mehsana District have been classified following standard classification. It is likely that U.S. Salinity classification might have to be modified, considering soil structure and type of clay as factors. In addition role of magnesium at high levels will have a little controversial behaviour and cannot be bunched with calcium in considering sodium adsorption ratio. An attempt has been made to assign some reasons for origin of salinity in tube-well waters. The two prominent geochemical types are found in the area. In Nadi-Kalol-Mehsana Na-Mg-\(\text{HCO}_3\)-Cl geochemical type of waters exist. Actually these are oil bearing areas. The area of Harrig-Saol has deep waters which show Na-Mg-Cl-SO\(_4\) geochemical type. It is possible to say by looking to agriculture which people carry out with saline waters that the classification should contain more than four classes for salinity as suggested by Banda.
In chapter V an attempt has been made to examine the various sources of origin of salt in North Gujarat. Many interesting geological and geochemical evidences present before us, a serious problem of considering different origins for the salt in the area: (1) According to geologists the Gulf of Kutch and Gulf of Cambay were once connected and Saurashtra was a rocky island. The remnants of the old sea is lake Nal which is a salt-water lake even today. (2) Salt deposits at Khargodha and Kuda which supply salt brine in lacs of tons per year. (3) Existence of oil bearing strata in Kalol-Kadia-Mehsana also support the view that during an earth movement sea became land and a lot of sea water was land-locked. However, the best information is supplied by stratification in salinity and even geochemical type; presence of huge amounts of MgCO$_3$, CaCO$_3$ and precipitated gypsum bands support the view that there has been sea water fractionation. In fact Goldschmidt considers gypsum formation, to have sea water origin. Again Bond considers that the ratio of Cl/HCO$_3$ can be used to decide the origin of salt. The tube-well waters may be considered diluted sea water and not concentrated river water. Not only the salinity of water, but also the salinity of soils substantiate the above view.

Chapter VI deals with the original contribution about the application of waste sulfuric acid in reclamation of saline-alkali land. Of course, sulfuric acid has been used
for saline-alkali land reclamation by many American Scientists. In reality the difficulties of dealing with sulfuric acid have been overcome because polythene earbays and polythene lined tanks are now available. In 1974, the chemists of Dudhsagar Dairy posed a problem to the Chemistry department, Gujarat University how to use one ton waste sulfuric acid per day. Thus the chemists of Dudhsagar Dairy and the team of chemists of the Chemistry department under the leadership of Dr. R.K. Shah started experimenting at two sites, namely Sagodia in Patan Taluka and Zilia in Chansra taluka. As a matter of fact the American Soil Scientist of U.S. Salinity Laboratory also gave his opinion in writing that calcareous Sodic Soils can be improved by sulfuric acid method. The Central Soil Salinity Laboratory in India has suggested sulfuric acid method for alkali soils only, but in the present work we find that in calcareous soils the infiltration rate improved very fast because there happens a Ca-aggregate formation which provide water channels and also the bodily dissolution of calcium carbonate particles provides porosity to the soil structure. In fact, the method is very quick because the sulfuric acid generates a concentrated gypsum solution which is also hot in the beginning. Ultimately, there will be gypsum formation which also may maintain high water and air permeability during the next cropping pattern. After the two trial experiments in 100' x 100'; many
sites were selected in North Gujarat. The Chemistry Department of University School of Sciences has reclaimed 400 acres of land by this method. The method provides confidence to farmers in saline-alkali land that their land can be improved within 10 days. Of course addition of water on the soil and providing drainage are essential stages of the process of reclamation. The method is significant from the point of view that there are 20 lac acres of saline-alkali land in Gujarat and one crore acres in the whole of the country. Again fifteen lac tons per year of sulfuric acid is produced in the country. If we consider that 7.5 lac tons is used for sulfonation and nitration reactions, in the synthetic fibers industry and in the testing of milk; these 7.5 tons after 50 % dilution will be useless for its original use and will make waste diluted sulfuric acid to be 15 lac tons per year. The problem is shall we put the acid to use and reclaim 7.5 lac acres of soil every year or shall we spoil our costly drains and also pollute the river streams by allowing a free flow of waste acid? Thus reclamation by acid method within 10 days is a challenging process for national development. It is curious to note that farmers not only get 30 % to 50 % more crops but some times if they grow cash crops like Zira (Cummin) they can get 5 times more income.
In chapter VII an attempt has been made to study seed germination under salinity condition and under alkalinity condition (by using soils containing different proportions of Na-soil plus Ca-soil). The general knowledge that wheat is a salt tolerant crop and that paddy is a alkali tolerant crop raises a curious question whether there can be further stratification of saline-alkali condition for different crop species. In fact in many regions in Gujarat a good crop of paddy is taken and poor stand of wheat is found in late winter in the same soil.

The seed germination study has indicated that for high salinity high alkalinity Barley is close to wheat, while Bajara is close to Juwar (Sorghum) for the low salinity low alkalinity range among cereals. Among oil seeds, castor oil seed has highest salinity and alkalinity tolerance while mustard has lowest salinity tolerance but medium alkalinity tolerance. Among pulses, Valor has highest salinity-alkalinity tolerance while Chana (Gram) has lowest salinity-alkalinity tolerance. Chola can tolerate low salinity but high alkalinity while Hung and Tuver have medium salinity tolerance but high alkalinity tolerance. Among vegetables, radish and turia have high salinity alkalinity tolerance, while guar has low salinity tolerance but high alkali tolerance, while dudhi has medium salinity and medium alkali tolerance. Of course, a still more critical study is required in this field. Actually
it would not be possible to consider any soil to be either saline or alkaline because both the aspects are interlinked. A saline soil gets leached in the rainy season or under irrigation-application, the salt goes to the lower level making the upper layer leached soil to be sodumized and turning them into alkali soils in dry soils. This soil is suitable for growing of paddy and the soil after rainy season when salt starts coming up can be used for growth of wheat but at moderate levels.