

Paper No. 235
Year 1940

**THE FORMATION AND THE
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The main object of this paper is to discuss the problem of salt in soils with reference to land deterioration as it affects the Government revenue and the Zemindar's income. Although the problem of Thur or Kallar was brought to the notice of the Punjab Government as early as 1908, the regular survey of affected land was carried out in 1972. It showed the problem of Thur as serious as that of waterlogging. Fields were considered to be damaged if their cultivation had been abandoned or their crop production had fallen below four anna crop. The presence of a white efflorescence over pulverised or swollen earth was the type of thur to be taken into consideration. It was estimated that 5 lakhs of acres had been abandoned for cultivation due to thur, the present rate of deterioration being 25000 acres per annum.

The source of the salt responsible for thur formation was believed to be the water-table. Thur appeared as a result of evaporation and transpiration at the soil crust surface. Thur studies therefore were confined to areas of high water-table. In America attention had been devoted to the addition of salt to the land by irrigation water. In order to investigate the real causes of thur formation on lands, soil surveys were carried out in the Lower Chenab Canal area where water table depth varied from 9 ft. to 40 ft. This study indicated that water-table might not be an essential factor contributing to the formation of thur. For further investigations the soil profiles were studied in fields where thur has appeared at the surface and the adjoining fields in which normal crops were grown. In thur lands, the salt was present throughout the depth of soil crust up to 10 ft. and the main zone of

accumulation of salt was 0 to 5 ft. These profiles demonstrated that both in the irrigated and unirrigated areas salts were generally present in the soil crust. The presence of salts in the soil under unirrigated land showed that their occurrence could not be due to addition made by irrigation water, but was a characteristic of original constituent of the soil crust. Formation of thur is dependent upon the original salt content of the soil crust.

Investigations by Puri indicate that in areas of rising water-table, if the soil crust is more than 10 ft. thick, the rise stops when the water-table touches the soil crust. This study leads to the conclusion that the water-table is unlikely to contribute salts to the soil surface when it is situated at a depth of 10 ft. Soil profiles in high water-table area, that had not gone out of cultivation, generally show a zone of salt accumulation below the surface indicating that even in high water-table areas, water-table itself is not such an important factor in thur formation as was once supposed.

The Irrigation practices in the fields under present delta are tilting the balance of salt movement towards the soil surface. As soon as the zone of accumulation of salt approaches such a depth from the surface that the concentration of salts can occur due to evaporation then the land becomes thur. It has been observed that the salt movement is seasonal and in the rabi season the conditions are favourable for appearance of salt at the surface whereas in monsoons, salt zone is depressed.

Before the commencement of irrigation, salt is distributed throughout the depth of soil crust and in the absence of irrigation water no movement takes place. With the introduction of irrigation the salts accumulate in a zone below the natural surface. The subsequent position of this zone depends upon the intensity of irrigation and the type of crop. If the quantity of water used is insufficient to balance the losses due to evaporation and transpiration and the zone of accumulation is within 10 feet of the surface then the tendency of this zone would be to move upwards. Experiments were started in the field near Jaranwala to examine the effect of irrigation pattern under various crops on the salt movement in soil crust. With the irrigation applied to cotton, salts have been removed from the surface and have formed a zone of accumulation at a depth of 6-7 ft. Rice fields are

heavily irrigated where the salts have been completely removed from the soil crust.

A soil containing calcium clay is permeable to water and air, and gives good crop yield. When a solution of sodium sulphate or sodium chloride is brought in contact with calcium clay soil, base exchange takes place, resulting in sodium clay which is alkaline in nature. This type of soil is not suitable for the growth of normal crops. The following standards were laid down for soil classification purpose based on salt content, PH value and the yield of crop;

- Type 1. Soils which are likely to give normal yield of crops have a salt content of 0.2% and PH value not higher than 8.5
- Type 2. Soils which will tend to reduce the yield of crops below normal have salt content below 0.2% and PH value ranging between 8.5 and 9.0.
- Type 3. Soils which are suited for limited type of cropping in the initial stages of irrigation. Their salt content is less than 0.5% and PH value between 9.0 & 9.5.
- Type 4. Salt soils that can be economically reclaimed have salt content above 0.2% while PH value below 9.0
- Type 5. Salt and alkaline soils which are difficult and expensive to reclaim having PH value always higher than 9.5.

The experiments were conducted at Chakanwali, Renala areas to find the methods for reclamation of the various types of soils and the financial aspects involved. It was found that the most suitable type of drainage method in high water table area is the open type drains. They kept the water table in motion which in turn removed the salts from the fields, increased soil aeration and thus allowed the normal crops to grow. The thur type of soils could be reclaimed with one or two rice crops but the rakkar type could be reclaimed in less than four Kharif seasons. It was estimated that the net cost to reclaim the land was Rs. 42 per acre and the land once reclaimed would remain fit for cultivation for a period of seven years. A financial study of commercial reclamation of 5000 acres block of deteriorated land shows that if there

are no calamities such as hail or crop disease, there will be a net profit of Rs. 30, 172 at the end of reclamation operation. At Renala it is observed that the leaching of thur land is not likely to cause any damage to the adjoining lands, and the local rise in water-table is a temporary phase.

The attack of rice borer caused reduction in crop yield and financial loss to the reclamation measure. Therefore a new variety of rice "Sathra" was introduced in Kharif 1938 at Kala Shah Kaku and in areas of Lower Chenab Canal and Lower Bari Doab Canal for reclamation purpose. It was experienced that this variety could stand a relatively higher salt content, needed less irrigation water, and gave a heavy yield. Two rice crops could be obtained resulting in reduction in overall reclamation cost. Reclamation through rice required extra water and therefore arrangements were made to frame new warabandi and excess water was supplied at the rate of 50 acres per cusec. The Zamindars are now becoming aware of the benefits of reclamation procedures evolved through these experiments and are willing to apply them on their thur lands.

The reclamation procedure of land involves levelling of the area and construction of drainage system. The area is divided into 1/4 acre plots with the main water course in the centre. If the water table is below 6 ft. no seepage drains are provided. In April water is allowed to stand in the field to a depth of four inches. In May when salts are washed down, the Sathra variety of rice is grown. The heavy irrigation eliminates the salts from the soil crust and the alkalinity removed by the action of roots of rice crop. The carbon dioxide formed by roots converts the sodium sulphate into sodium bicarbonate and the soil becomes permeable. In order to re-establish the nitrogen balance in the soil leguminous crops like gram, berseem are grown following rice crops. In a seep water-table area if the salts have been washed either to a sand layer or with 10 ft deep soil crust, it is considered that the land had been permanently reclaimed. If there exists a zone of accumulation within a 10 ft. deep soil crust, then the reclamation should be regarded as temporary.

The difficulties encountered in the reclamation of thur lands are the non availability of extra supply in the distributaries during Kharif season and in case the extra water is allowed to run in the channel, the

tail out areas are unable to get their due share of irrigation supplies because of over withdrawal by head reach outlets. To overcome such problems it is essential to consider reclamation of land at the early stage of appearance of thur when less water is required to reclaim the land and the use of Gibbs module in head reaches. In large areas of thur land where no field bund exists, the problem arises from interference of run off containing saltish water with the progress of reclamation operation in the adjoining lands. In soils with high salt content and low degree of alkanisation, leaching is very rapid resulting in loss of irrigation water and low crop yield. The barrani hill varieties have been introduced to overcome this problem.

It is necessary to determine the salt content of soil through soil surveys to ascertain the degree of deterioration of land under cultivation. To prevent thur formation, it is necessary to reduce intensity of irrigation and increase delta with the introduction of suitable variety of rice crop. A subject which is now receiving considerable attention is the water requirement of crops and its relation with the reclamation of deteriorated lands. It is suggested that the agricultural system of deteriorated lands should be altered temporarily to include rice in crop rotations and the irrigation supplies should be enhanced.