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The Upper Chenab Canal feeds Lower Bari Doab Canal by crossing Rechna Doab with a full supply discharge of 12000 cusecs. The danger of water-logging was anticipated by the designers as the alignment crosses all the drainage lines of the Doab. As a preventive measure, the area was divided on the basis of depths of spring level of more than 35 ft, between 30 & 35 ft and less than 30 ft, respectively. A & B zones were perennial having 60% intensity of irrigation whereas C zone was non-perennial with 25% irrigation intensity.

The Upper Chenab Canal started functioning with its full capacity in 1916 and waterlogging was reported in 1918. The waterlogging went on spreading and became very serious in 1925. Government ultimately appointed a Waterlogging Enquiry Committee for the investigation of causes of waterlogging. This Committee accepted 28,500 acres as damaged in 1927, and a close and constant watch on the situation and a systematic treatment of the subject were considered essential. This led to the establishment of Waterlogging Board in 1928.

For the discussion in this paper, the command area of this canal is divided into four tracts according to the intensity of irrigation, the distance from the main canal and the anti-waterlogging measures undertaken. The area within a distance of 3 miles on both sides of the canal is termed as Tract I. The tracts lying within the irrigation boundary of Raya Branch and Nokhar Branch are called as Tract II & III respectively. Tract IV is irrigated by perennial distributaries of the

Upper Chenab Canal and it is lying between Main Line, Upper Chenab Canal and the irrigation boundary of Lower Chenab Canal.

The maximum waterlogging occurred in Tract I and in this tract, maximum expenditures were also incurred. Pipes at regular intervals were fixed all along the main canal for monitoring of anti-waterlogging measures. Average rise or fall of water table was plotted for three Divisions, Marala, Gujranwala and Sheikhupura. It was apparent from these graphs that water table was rising in Gujranwala and Sheikhupura Divisions even before the opening of the canal but this rise was accelerated from the year 1916 when the canal started running with high supplies. In Marala Division, the rate of rise slackened after 1918. The maximum rise was in 1926, the year of heavy rainfall and from 1926 to 1933, there was practically no rise in all of the Divisions. Conditions within half a mile of the canal were very bad. In 1923, 65 miles were reported to have been affected which caused great alarm. Seepage drains along the canal, lowering full supply levels of the Main Canal, tube well pumping, restriction of supply for irrigation, pumping in local areas, surface drains and tail reach diversion were some of the measures adopted singly or jointly.

First signs of waterlogging appeared along the canal in the form of water standing in borrow pits, pools and other low areas. Seepage drains along the canal, therefore, seemed to be a good measure for the control of water-logging and a large number of constructed drains did help to give local relief. But because of increase of percolation head, springs started apperaring in the bed, caused rapid silting up of the drains, and did not help in the control of water table. Further these tended to increase seepage losses from the canal owing to the increase of percolation head and most of these drains, therefore, have been abandoned.

Lowering of full supply level of the Main Canal was also done to get relief in waterlogging. Firstly, observations to examine the effect were taken from open pits but these were discarded because open pits were not reliable as rain and irrigation water entered into them. The pits were replaced by pipes with filter points at the bottom. A number of graphs and tables conclusively proved that the lowering of supply levels did not have any marked effect on the water table in the tract outside

half a mile of the canal. There was no practical effect on the belt between half a mile and three miles from the canal.

After the successful control of waterlogging in Califronia, tube wells were installed in the Gujranwala and Ferozepur areas. The results show that tube wells are not a good remedy for lowering the water table permanently and even for temporary lowering they are only effective so long as there is no rainfall. These have to be installed at one mile intervals and will be very costly for Upper Chenab Canal comand area of over 2000 square miles. The success of tube wells in California may be due to the different geological conditions of subsoil strata as the soils there are much coarser and more porous containing an admixture of sand and gravel and depression heads are consequently much bigger.

Another measure adopted for control of waterlogging was restriction of water supply for irrigation. The results showed a very low effect on the water table and it must be discarded as it also effects cultivation.

Pumping in local areas was done at tails of certain seepage drains which had no gravity outfall and near certain important towns where the water-table was rising dangerously close to the foundations of houses causing settlements. These proved to be very useful for control of water table locally near large towns and villages, but in general they did not show any considerable effect.

Ferozewala, Khoth Nalla and Nikki Deg were the only surface drains constructed within the 6-miles belt of the canal. These drains have been very beneficial and constitute an efficient drainage.

The tail reach of the Upper Chenab Canal below R.D. 280,000 runs almost parallel to the river and waterlogging in this area became very serious. Tail reach of the canal was diverted via Deg Diversion Channel. The effects of this diversion are not yet known.

Tracts II & III i.e. the areas commanded by Raya & Nokhar Branches did not experience any significant waterlogging and in both tracts, the water-table is steady at about 11 ft below ground at present. In Tract IV, water-table is generally rising and uptil now, no measure has been taken. The water table is at present about 9 ft below ground level.

Waterlogging also affected the tract on the right side of Main Line above Nokhar branch. The Sambrial-Aik Nallah Drainage Scheme has changed the entire area and at present there are no signs of waterlogging.

In the second part of the paper general causes, mechanism and effects of waterlogging and anti-logging measures in the Punjab have been discussed. There was no planned policy till 1933 when first five years plan of drainage construction was adopted on the author's proposal. This plan was necessary in order to secure land from the evil progressing of waterlogging.

It can be said that in the pre-canal period, the water table was in state of equilibrium i.e. inflow was equal to outflow and the subsoil drainage was sufficient to cope with the inflow. Before the construction of canals in Doab, infiltration from rivers towards bottom of the trough, absorption of rainfall and subsoil flow from upper regions of the Doab constituted inflow whereas outflow was the subsoil flow towards the lower regions. After the construction of canals, seepage from canals disturbed the equilibrium condition because of insufficient subsoil drainage. The studies of this area show that waterlogging is to a large extent due to seepage from the canal system and to a small extent due to increased absorption of rainfall resulting from breaking up of new areas for cultivation.

The extent of waterlogging can definitely be reduced if amount of inflow into the subsoil can be reduced. Irrigation canals, subsoil flow from upper regions and rainfall are the source of inflow. Irrigation can not be reduced, seepage from canals can be controlled by lining but uptil now no lining material has been found which would be effective as well as durable, cheap and capable of being applied with in the short time during closures. Subsoil flow from the upper reaches is a natural phenomena and, hence, can not be stopped. The only option left to reduce inflow in the Doab is the check of rainfall run-off. A large amount of water can be drained out naturally as the country is made up of water sheds and drains with almost scientific regularity. Artificial channels of suitable size should be provided along natural drainage lines so as to carry away the storm water rapidly to the rivers without causing undue flooding in the surrounding area. Greater number of

these drains will drain out faster the run-off. This method is only beneficial in the areas where rainfall is the main cause of waterlogging. In other areas, the lowering of water table in the upper reaches of the Doab through lining of canals can also be done.