A NOTE ON CAPILLARITY AND SUBSOIL WATER-TABLE

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It has been observed in the Punjab, Sind and other provinces that when there has been a slight shower of rain or even a small amount of irrigation over a wide area, some of the wells, especially the shallow ones rise out of all proportion to the amount of rain or irrigation. The observation pipes which have been put in to record water-table also behave similarly. This question had been referred to us many times, but they could not then be explained. Calculations made on the basis of the permeability of the strata could not account for even a small fraction of such a rise.

An experiment has now been carried out in the Irrigation Research Institute, Lahore, which explains this phenomenon.

An iron tank of about four feet in height and three feet in diameter has two side tubes with strainers fitted near the bottom. The tank is then filled with fine sand and water. When the sand has been packed completely,

Fig. 1

the water in the tank is drained off till it stands about half-way in the side tubes, which are about one centimetre in diameter. A photograph of the tank and those of the side tubes with the levels of water in them is shown in Fig. 1.

If the tank is now allowed to remain for a day, the surface of the sand being exposed to the air, the water-level in the side tubes sinks down by ten centimetres. Now experiments had shown that the amount of evaporation from the surface of the sand could not account for a fall in the level of water in the subsoil in the tank for any thing of this order. The fall of level of water in the side tubes was therefore surprising.

About one hundred grams of water was then sprinkled on the surface of the sand when almost instantaneously the water level in the side tubes began to rise and reached about eight centimetres. Now the amount of water sprinkled could only cause a rise of about 0·04 of a centimetre in the tank taking the pore space to be forty per cent. The abnormal rise of the level of water in the side tubes was therefore not indicating what was taking place in the water level in the body of the sand. The experiment thus provided a clue to the explanation of the abnormal behaviour of wells in the field referred to in the beginning of the note.

The reason for the rise of the level in the tube is this. Water is drawn up by capillarity through the fine pores of the sand and when it reaches the surface of the sand it begins to evaporate. A large number of concave menisci are formed in the interstices near the surface and these exert a negative pull. The water in the side tube is thus held down by this pull of the menisci in the sand. As soon as water is sprinkled on the surface of the sand, free surfaces are formed and the concave menisci are flattened, finally of course forming a continuous flat surface of water. The negative pressure decreases and causes the water in the side tubes to rise by a height which is many times that in the main tank. The action in the wells is also similar.

Any process which flattens the concave menisci causes the water in the side tubes to rise, and any process which increases the concavity, such as evaporation or putting dry sand at the top of the wet sand will cause the level in the side tubes to fall. It is not so much the amount of water evaporated or added on the surface which is the guiding factor in the fluctuation of the level in the side tubes as the negative menisci and the consequent change of pressure. The rise in the tube or in a well in the field is thus not an indication of what is really taking place within the subsoil, unless the other factors in the surrounding field are known. It is remarkable that a phenomenon as surface tension should play such an important rôle in subsoil observation.

Three main factors controlling this rise in the tube are (1) the particle size, (2) the height of the free surface of sand above the water in the tank and (3) the surface tension of water. The second factor brings in what is generally known as the moisture content, field capacity and other secondary effects.

The work has only been begun but in view of the bearing of the results on many engineering and agricultural problems we thought it fit to publish this preliminary note.