IS SALT IN SAMBHAR LAKE WIND-BORNE FROM THE RANN OF CUTCH AND THE ARABIAN SEA?

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The problem of salt in inland lakes has engaged the attention of many workers on the subject. The origin of salt in the lakes of Rajasthan have been attributed to the drying up of an inland sea, salt springs in the crystalline rocks, and to the products of weathering of the rocks and the bringing in of the salts by surface drainage to the lakes with little or no overflow. Holland and Christie (1913) considered these explanations and postulated a new theory about 40 years ago. According to this theory, the salt is brought by strong winds during the hot weather from the evaporation of sea spray from the Arabian Sea coast, and from the dry salt deposits in the Rann of Cutch to Rajasthan in general, and mainly from the Rann of Cutch to Sambhar Lake in particular. The southwesterly winds which blow during the period carry a large amount of sand and salt particles which is dropped when the velocity of winds decreases at night, and once dropped the force of wind is not enough to lift up the particles except near the coast whence they may be picked up again and retransported till the wind drops during the next night. The theory has been more or less generally accepted. In the Symposium on Rajasthan Desert in March 1952, Godbole (1952), however, objected to the theory of Holland and Christie and has since put forward the theory that the salt in Sambhar 'is the result of chemical action among residual solutions during the post-transgressional phase of the great Tethys (sea) at the end of the Tertiary age and the period following it'. During the discussion that followed Godbole's paper in the Symposium, it became clear that a detailed examination of surface and upper winds was necessary with a view to decide whether the salt in Sambhar Lake could have been borne by wind from the Rann of Cutch. Such an examination of wind data has been made in this note.

2. It should be mentioned that we have no information about the strength of the winds and the character of wind circulation more than three-fourths of a century ago, but in this note we are assuming that the wind strength and pattern were more or less the same as they have been during the last 30 years.

3. The mean winds at the surface and at levels of 0·3, 1·0 and 2·0 km. in the morning and evening in the months of April to August, and in the morning only in October and January are given in Figs. 1–12. In these figures, the wind arrow ending at the station shows the direction from which wind blows and each feather ( ) represents a mean speed of 10 knots or nearly 11 m.p.h., and each half feather ( ) represents a speed of 5 knots or 5·5 m.p.h. When speed is less than 3 knots, only direction is shown by an arrow without any feather. Thus, in the chart for surface in Fig. 1, wind at Karachi is blowing from WSW with a speed of 5 kts.; at Jodhpur, direction is WSW, but the speed is less than 3 knots. In the chart for 0·3 km., wind at Ahmedabad is from NW and has a speed of 15 knots.

4. In these charts, S is the position of Sambhar Lake and C is the point of the Rann of Cutch nearest to Sambhar. To examine the question of transport of salt by wind, let us start with the wind at surface at C (April-morning, Fig. 1), and draw the trajectory of air movement, a line drawn following at each point the wind obtaining there, showing the direction in which salt from C would

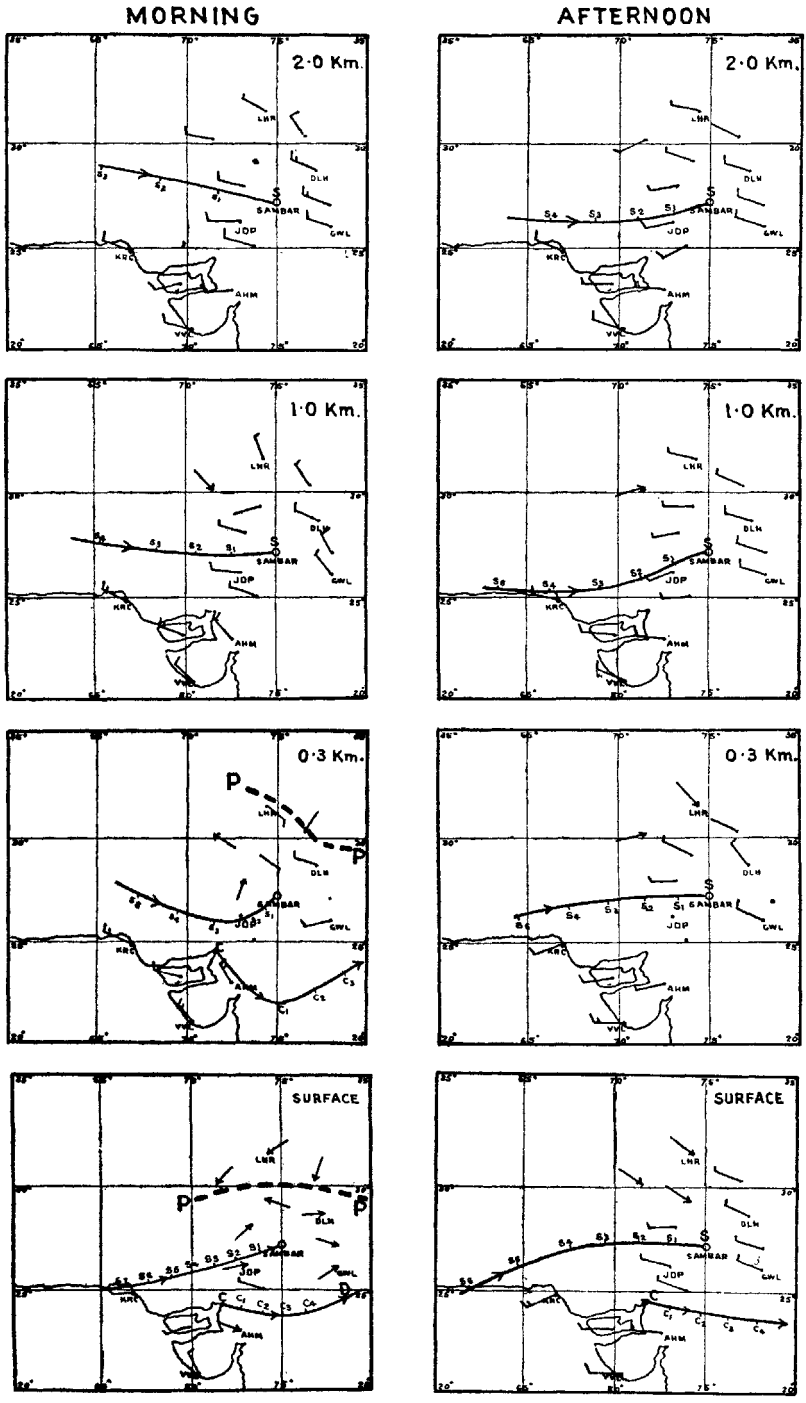

FIG. 1. FIG. 2.

MEAN WINDS IN APRIL.

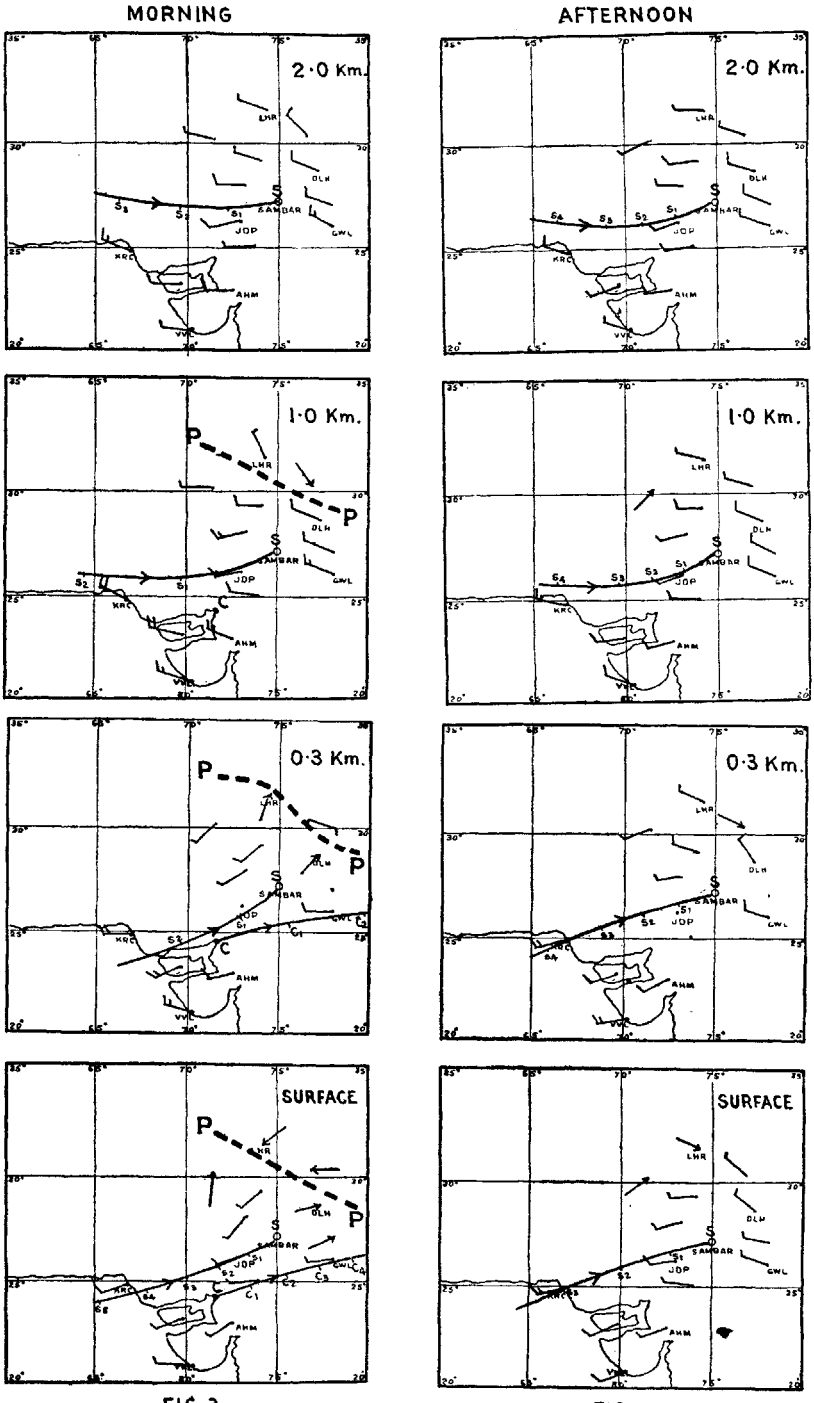

FIG.3. FIG.4.

MEAN WINDS IN MAY.

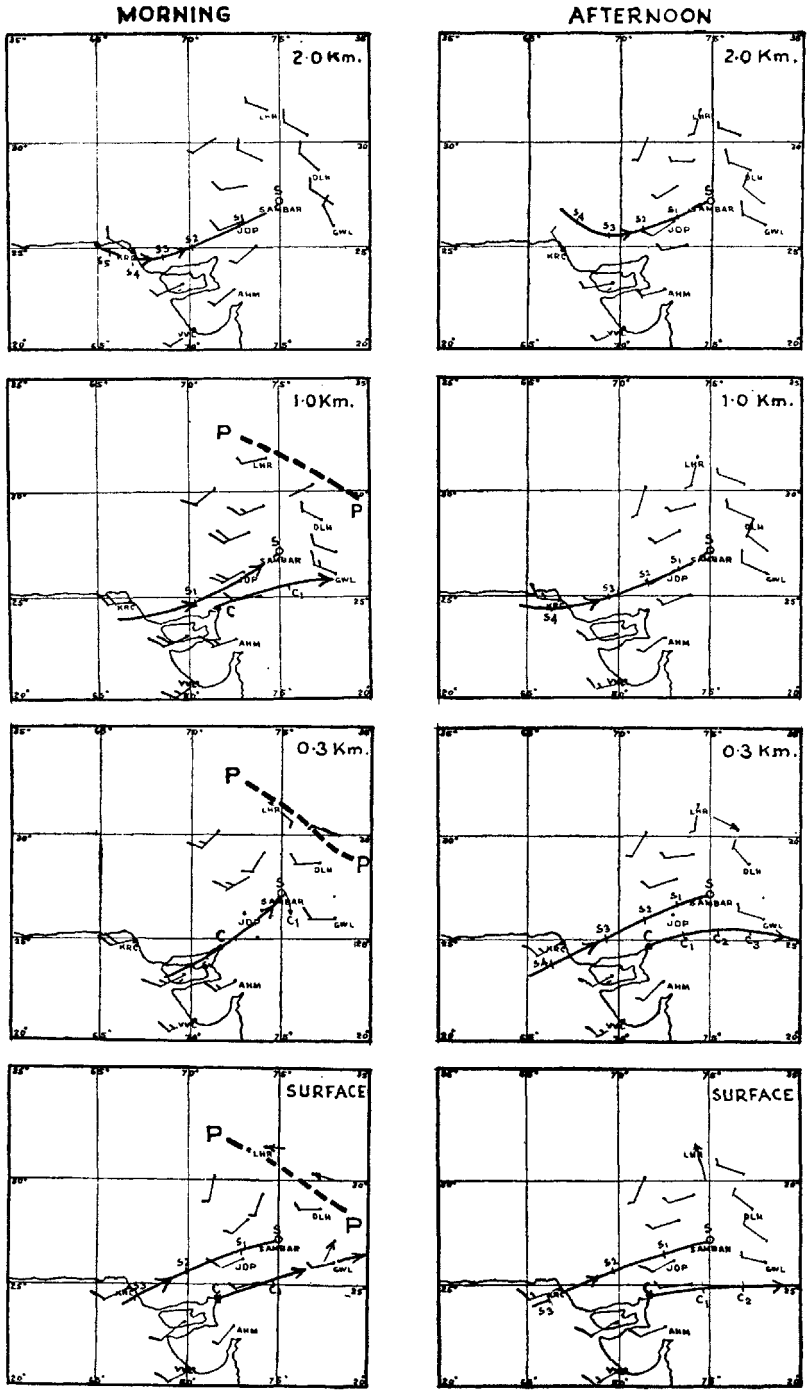

FIG. 5. FIG. 6

MEAN WINDS IN JUNE

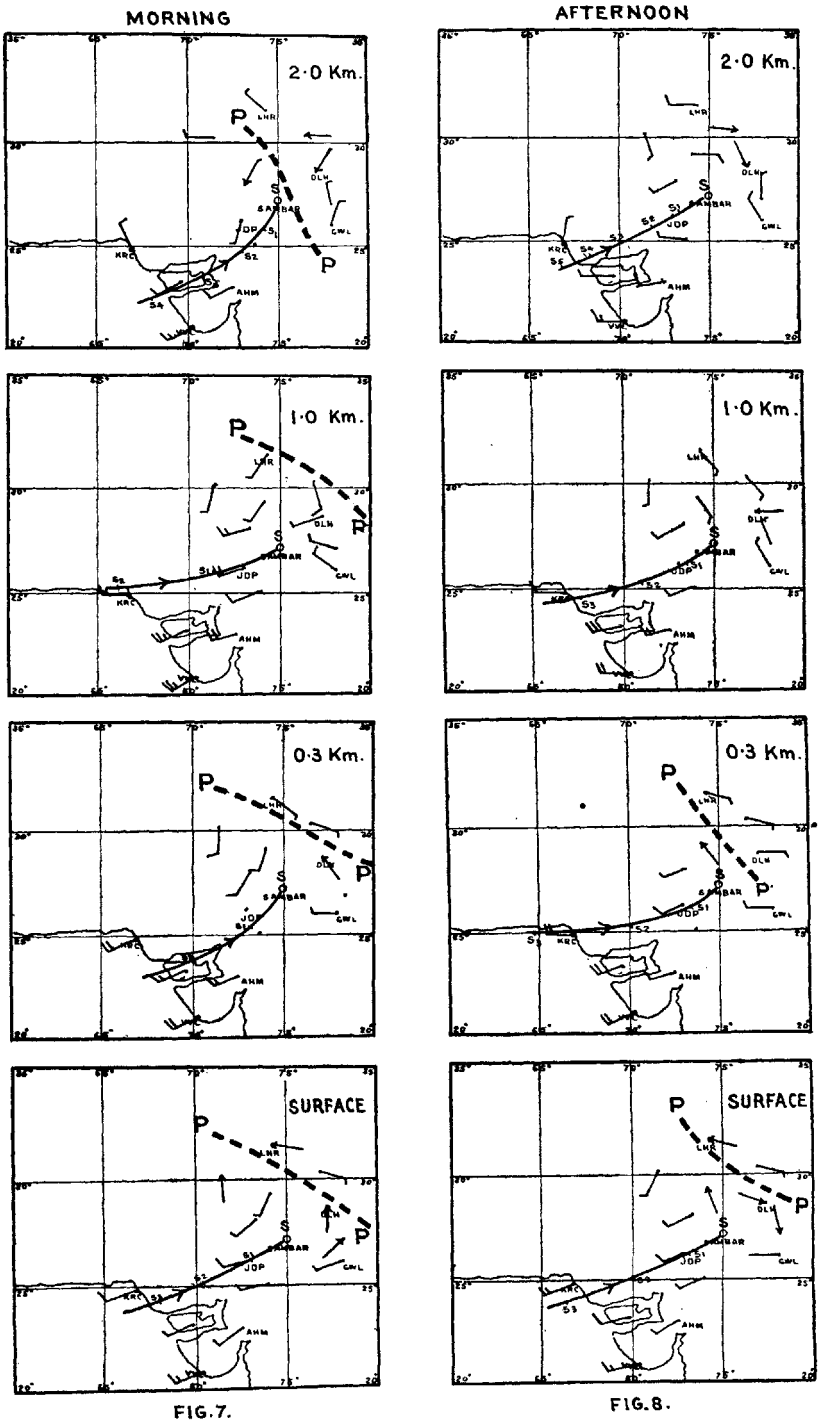

FIG.7. FIG.8.

MEAN WINDS IN JULY.

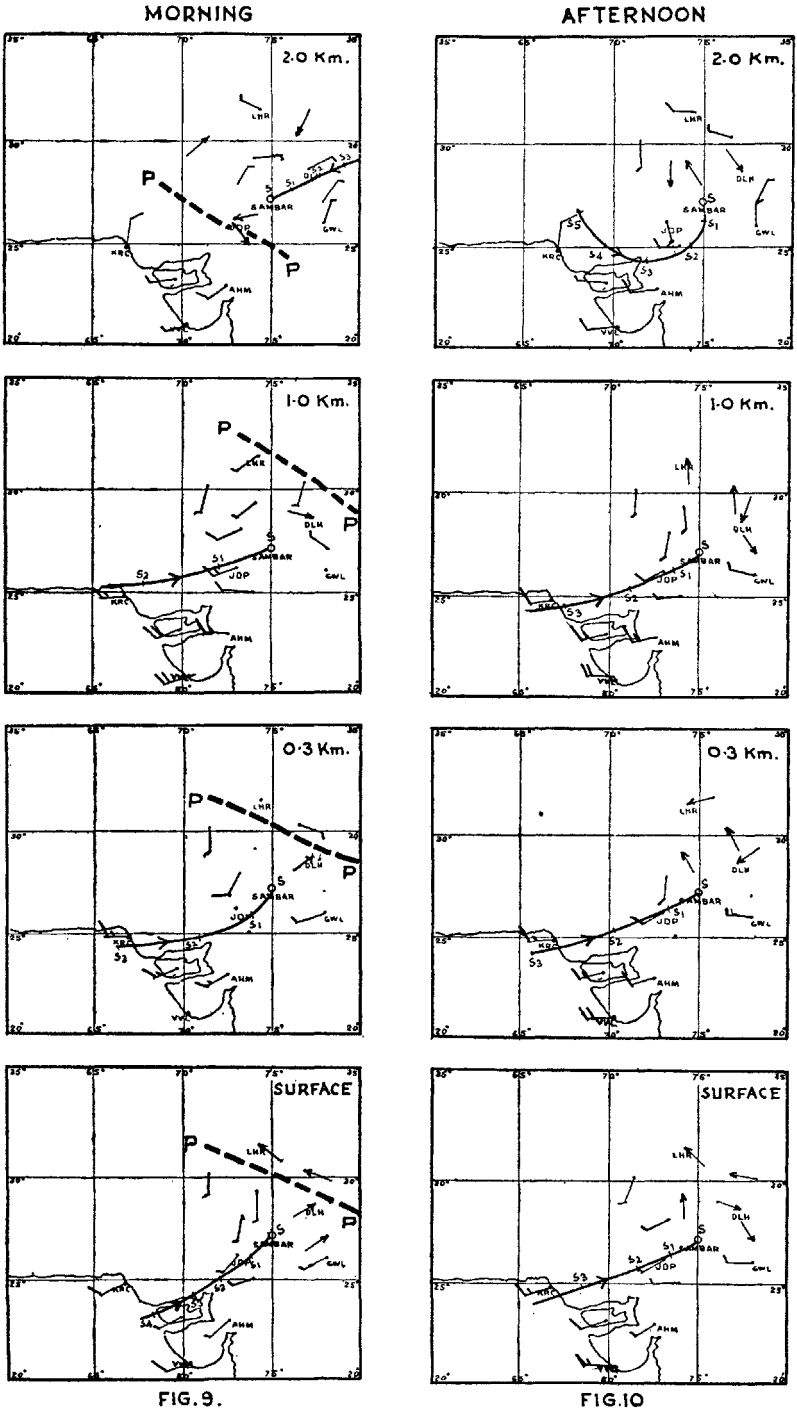

FIG. 9. FIG. 10

MEAN WINDS IN AUGUST

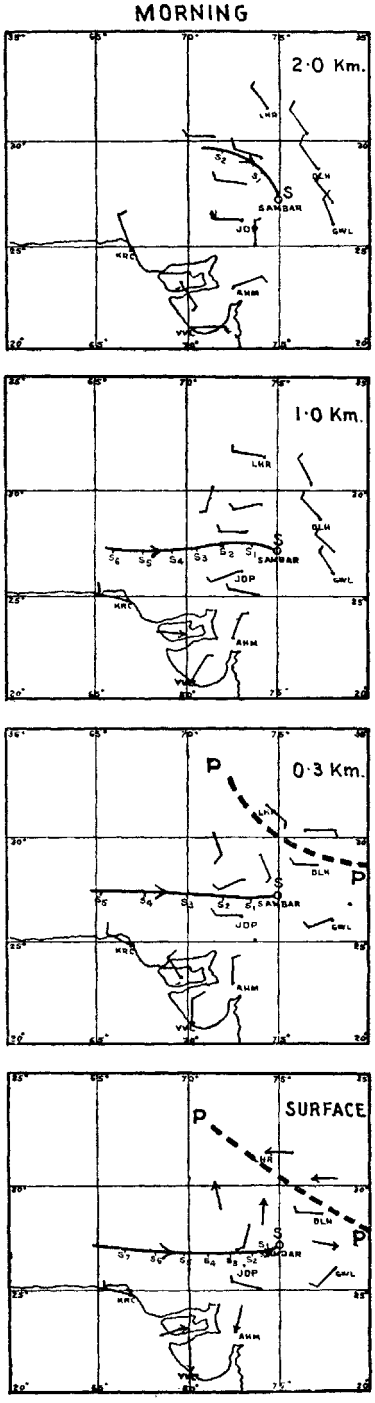

FIG.11.
MEAN WINDS IN OCTOBER.

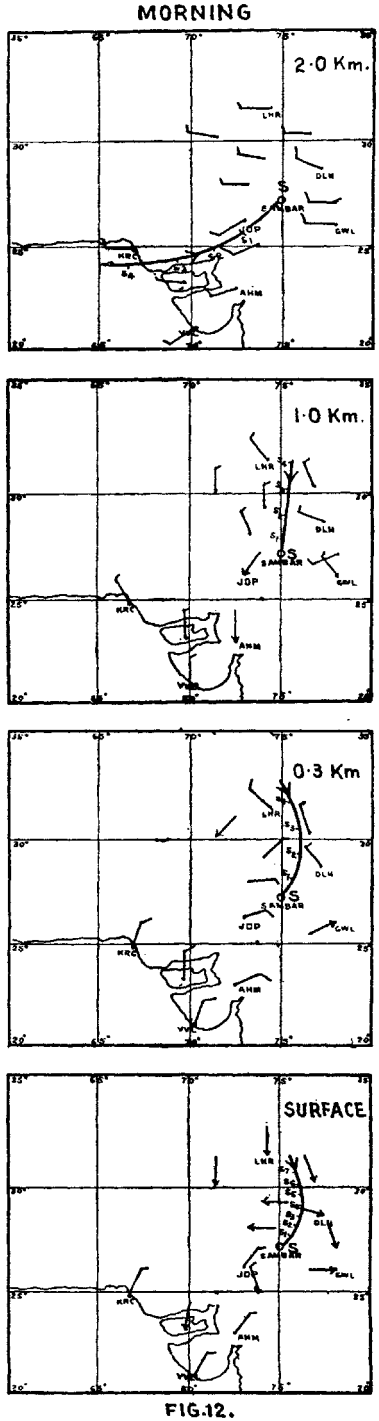

FIG.12.
MEAN WINDS IN JANUARY.

be carried by the wind. The speed in the region traversed is of the order of 3 m.p.h., and so the salt will be carried about 72 miles in a single day. The point the salt will reach at the end of a single day's journey is indicated by C_1, that it will reach after two days' journey by C_2, etc., etc. It will be seen that air which starts from C and is carried near the surface will not eventually arrive at the Sambhar region. Other points in the Rann of Cutch are even less favourably situated for transport of salt by winds to the Sambhar region. Conversely, one could start from S and trace the source region wind from which eventually arrives at Sambhar. Such a line has also been drawn in Fig. 1 (Surface) and the points representing one day's journey, two days' journey, etc., indicated by the points S_1, S_2, S_3, S_4, etc. It will be seen that sea air from near Karachi or the Persian Gulf could reach Sambhar region in about 6 to 7 days in April (see also Fig. 2; afternoon winds). At the height of 0·3 km., wind arriving at Sambhar in April is originally from Baluchistan, according to the morning winds and either from Baluchistan or west Mekran coast, according to the afternoon winds (Figs. 1 and 2). Greater heights are even less favourable.

5. Lines like S, S_1, S_2, S_3 tracing the source of supply of air to Sambhar, . . . and C, C_1, C_2, C_3 indicating the regions where air from the Rann of Cutch goes, have been drawn in the charts for other months wherever it was considered they would be helpful.

6. The two factors regarding wind which have to be considered are direction and force. We will consider direction first. From the figures 1–12 it will be seen that only during May to August (winds for months other than those for which figures are given have also been taken into account) and perhaps during part of April is the wind direction favourable for transport of salt by winds from the Arabian Sea to North-East Rajputana and Sambhar Lake region. If we, however, consider transport of salt from the Rann of Cutch to the Sambhar Lake region, the conditions are favourable only during June to August at a few of the levels during only part of the day. Holland and Christie's supposition that winds are favourable for the transport of salt from the Rann of Cutch to the Sambhar Lake region during the summer months of April, May and June—the ground being wet in July and August after the break of monsoon in June—does not appear to be borne out, except in June during morning and at only 0·3 and 2 km. levels but not at the surface and 1 km. level. We will now consider the force of wind. We will not consider here whether the wind is strong enough to lift up salt and to carry it along. We will take it that the wind near the sea and along the Rann of Cutch is strong enough to lift up salt and carry it along and also that there is enough salt dust available in the Rann of Cutch in the summer months. From the figures it will be seen that in no month is the wind strong enough to carry the salt lifted up in the morning from the Rann of Cutch more than half way to Sambhar Lake by the evening. In the night two things can happen—one is that the salt is carried on during night (when the surface wind drops to about 2/3 the value during daylight hours, but there is no large diminution in winds at 0·3 km. and above) and the other is that the salt is dropped in the evening and picked up again next morning. If the salt is carried on during the night there is no reason as to why it should be dropped in Sambhar Lake region more than elsewhere along the route before and beyond the Sambhar Lake. During certain months at some levels there is an opposing wind current but this is generally to the north of Delhi as shown by thick dotted lines PP in the relevant charts. If we postulate that the salt is dropped during night and picked up again next morning it would imply that the salt is being carried in the layer below the ·3 km. level as there is no appreciable decrease in wind strength at ·3 km. level and above, and that in this case it is unlikely that the wind-borne salt from the Rann of Cutch would reach the Sambhar region. Again, even if the salt does reach the Sambhar region and is dropped there, it is likely to be picked up again and carried away beyond this region, as there is not much difference in wind strength over the Sambhar and adjoining regions.

7. An examination of the figures indicate that the winds are more favourable for transport of salt from the sea and Rann of Cutch to Jawai and Banas catchments and the lakes near Ajmer and in South-East Rajputana, which all contain fresh water, than to the Sambhar Lake region. We have considered here the mean wind, but the results are not likely to be much different if we take into account winds for individual days for a long period.

8. Again, if the salt in Sambhar region is wind-borne it is likely to be distributed more or less evenly and since there is not much difference in rainfall over the region, one would expect the chloride content in the water of the different rivers in the Sambhar region to be similar, but actually there are very large differences (*vide* Table on p. 159 of Holland and Christie's paper).

9. It will be seen from the preceding paras that it is unlikely that the main origin of salt in Sambhar Lake and also, *a priori* in other lakes in North Rajputana is windborne from the Rann of Cutch or even from the Arabian Sea.

Summary

Many explanations of the origin of salt in Sambhar Lake have been given, the generally accepted one being that of Holland and Christie, advanced about 40 years ago, that the salt is borne by wind from the Rann of Cutch during the summer months. Godbole has recently objected to the theory. In this note the surface and upper winds have been studied with a view to examine whether the salt in Sambhar Lake could have been wind-borne from the Rann of Cutch, and the Arabian Sea. It is found that it is unlikely that the salt in Sambhar Lake and also in other lakes in North Rajputana could have been wind-borne from the Rann of Cutch or even from the Arabian Sea.

References

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Holland, T. M. and Christie, W. A. K. (1913). The origin of salt deposits of Rajputana. *Rec. Geol. Surv. Ind.*, **38**, pt. 2, 154–186.

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