551·573 : 551·508·72

Suppression of water evaporation by monolayers of octadecyl alcohol, glycol mono-octadecyl ether in petroleum ether

S. C. BHATTACHARYA

Meteorological Office, New Delhi

(*Received 15 March 1964*)

ABSTRACT. Experiments on suppression of evaporation were conducted during 1963-64 at New Delhi in the open in eight USA 'A' pans by using varying quantities of the solution of octadecyl alcohol and glycol mono-octadecyl ether in petroleum ether. The results of these experiments have been reported in this paper. It is noticed that the effect of the above suppressant is more pronounced at comparatively low air and water temperatures. It is also seen that octadecyl alcohol and glycol mono-octadecyl ether are more efficacious for the purposes of reduction in water evaporation than cetyl alcohol.

1. A number of experiments under semi-field condition of evaporation suppression from water surface by employing monolayers of long chain molecule has been conducted during 1963 and early 1964 at New Delhi. The experimental set up and the procedure adopted were those described in a paper presented at the Symposium on Water Evaporation Control held at Poona, during 17-20 December 1962 (U. K. Bose, UNESCO/NS/9, Report of the Symposium on Water Evaporation Control under publication). The arrangement, briefly, consists of eight USA 'A' pans nearly symmetrically placed in a circle of diameter of about 38 ft and the ensemble is protected from extraneous interference by a chicken-coup conical tent. The USA 'A' pans were maintained according to the prescribed standard procedure *vide U.S. Dep. Agric. Tech. Bull.* No. 271, 1931 and *India met. Dep. Agrimet. Tech. Circ.*, No. 5 (Revised). In one out of the eight pans, a fixed point gauge has been employed and the others have a hook gauge for recording measurements of the level of the water. The water employed in the pans was from municipal filters. In the present set of experiments the monomolecular layer produced was of octadecyl alcohol and glycol mono-octadecyl ether mixed in different proportions. The substance was dispensed as a solution in petroleum ether. A definite number of drops of the solution were dropped on the water surface. In all experiments, control observations were taken by keeping untreated pans next to treated ones, readings of which enabled one to work out the extent of suppression of evaporation expressed as a percentage. All pans were stabilized before commencement of evaporation suppression experiments. With this arrangement, the values of suppression of the evaporation for a period of 24 hours were obtained with considerable degree of accuracy.

2. One case of particular interest and significance is reported here in detail. A solution of 0·165 gm of octadecyl alcohol, 0·333 gm of glycol mono-octadecyl ether in a solvent of 33·3 cc. of petroleum ether was prepared. At 1100 hrs of 19 December 1963, 120 drops, 80 drops and 40 drops of the solution were dropped in three different evaporimeter pans (these are numbered for our convenience as 63, 61 and 65). The alcohol and ether in solution rapidly spread on the water surface, which consequently acquired a very characteristic glassy appearance and later became mirror-like flimsy patches. It was noticed that the fluid spread rapidly to produce the film covering the entire surface and remained intact for a number of days till it partially collapsed due to rain and hail on 29 December 1963. The photographs (Figs. 1a to 1c) show the treated surface.

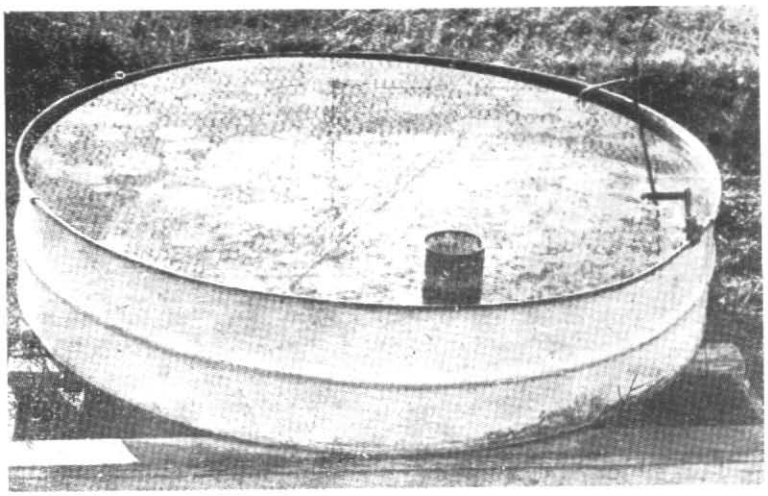

Fig. 1 (a)

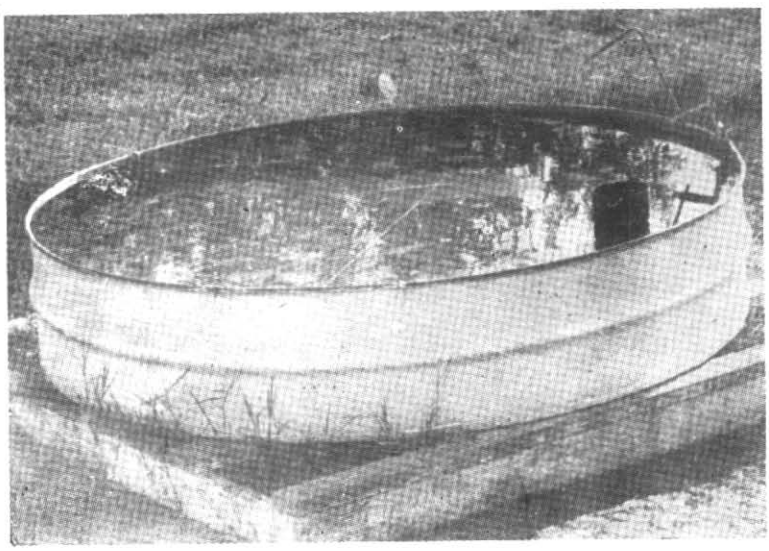

Fig. 1 (b)

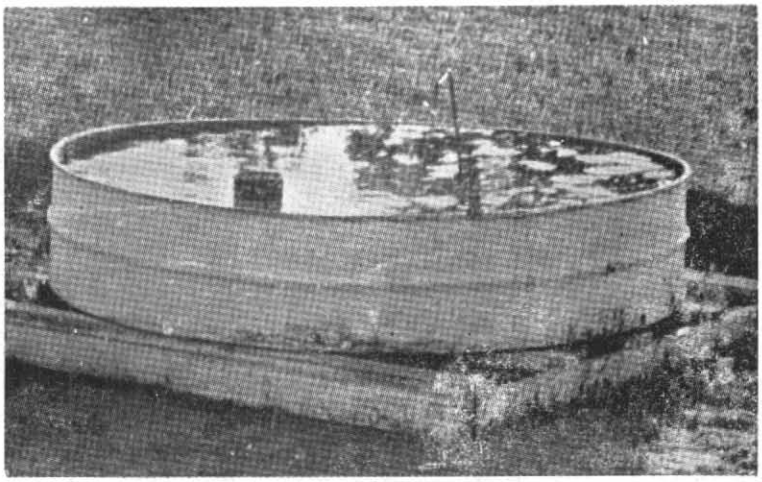

Fig. 1 (c)

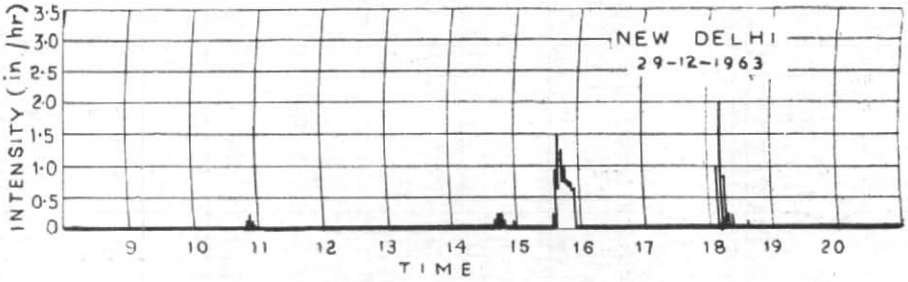

Fig. 2

3. The extent of suppression of evaporation due to monolayer expressed as percentage (for periods of 24 hrs—(*i*) from 1030 hrs of the day to 1030 hrs of the following day and (*ii*) from 1630 hrs of the day to 1630 hrs of the following day) from 20 December 1963 to 3 January 1964 are shown in Table 1.

4. On 29 December 1963, there was a sharp shower accompanied by hail from 1805 to 1830 hours. The shower affected the film surface as could be seen from the evaporation suppression of the 31st. However, the evaporation suppression reappeared after a lapse of over 24 hours. No fresh dose of suppressant had been added to any of the pans during this period. Fig. 2 shows the record of the rainfall intensity recorder on 29 December. It will be seen from this that the highest intensity of 32·3 mm (1.27″) per hr was confined only for a short period of time. The total rainfall on this day was 20·7 mm (0.81″). It appears that the rainfall could not completely wash away the film from the surface of water because the film seems to have reappeared from the residual film pushed to the sides of the pan. The suppression of evaporation continued for a few more days after the rains even though no fresh solution was added to the pans. The water temperature also showed a rise and might have aided the reappearance of the mono-molecular film.

5. On some days the values recorded in the afternoon by the hookgauge in pans treated with 120 and 80 drops were found to

TABLE 1

Date	Pan No. 63 (120 drops)				Pan No. 61 (80 drops)				Pan No. 65 (40 drops)			
	(a)	Temp. (°C)	(b)	Temp. (°C)	(a)	Temp. (°C)	(b)	Temp. (°C)	(a)	Temp. (°C)	(b)	Temp. (°C)
December 1963												
20	64	0·6	71	7·2	60	1·1	60	7·8	50	1·1	40	7·8
21	60	0·6	70	7·2	60	1·1	60	7·8	55	1·1	50	7·8
22	68	0	70	7·8	58	0·6	63	7·8	56	0·6	63	7·8
23	69	0·6	67	6·7	62	0	66	7·2	58	0	65	7·2
24	74	0	80	7·8	80	1·1	80	8·3	71	1·1	65	8·3
25	73	0·6	75	7·8	76	0·6	74	7·8	71	0·6	70	7·8
26	71	1·1	72	7·2	72	1·1	72	7·8	64	1·7	68	7·8
27	70	—1·1	58	6·1	63	—0·6	65	6·7	60	—0·6	54	6·1
28	65	—0·6	72	6·1	60	0	70	6·7	60	0	63	6·1
29	Intermittent rain. Shower with hail in the evening. Total rainfall 20·7 mm. Fresh observations were taken.											
30	—	—	—	—	—	—	—	—	—	—	—	—
31	36	2·2	68	8·9	6	2·2	54	9·4	25	2·2	71	9·4
January 1964												
1	66	0·6	63	7·8	57	0·6	57	7·8	59	1·7	62	8·3
2	60	0·6	57	7·2	56	0·6	—	7·2	55	0·6	60	7·2
3	35	0	10	5·6	—	—0·1	—	6·1	10	0	—	6·1

(a) Percentage reduction in water evaporation from 1030 hrs of the day to 1030 hrs of the following day
(b) Percentage reduction in water evaporation from 1630 hrs of the day to 1630 hrs of the following day

be more than or equal to the values recorded in the morning. This seems to be due to the fact that the water level fell by only a very small amount due to very high percentage of evaporation suppression. Therefore, the difference in the levels was well within the experimental error. It must be pointed out that we can detect only the cases of positive errors (level being read too high).

6. Another experiment to study suppression of evaporation by monolayers of octadecyl ether and alcohol *vis a vis* that of cetyl alcohol under conditions of very low water temperatures was undertaken between 6 to 13 February 1964 which is as detailed below—

A solution was prepared in 16·6 cc of petroleum ether with 0·0825 gm of octadecyl alcohol, 0·1665 gm of glycol mono-octadecyl ether and another solution was prepared with 0·5 gm of cetyl alcohol dissolved in 33·3 cc of petroleum ether. At 1000 hrs of 5 February 1964, 120 and 80 drops of octadecyl solution were dropped in two pans Nos. 63 and 65 and 80 drops of cetyl solution were dropped in pan No. 61. Mirror-like flimsy patches formed in pan Nos. 63 and 65 but a very thin film (not showing the mirror-like effect so prominently) appeared in pan No. 61. Table 2 gives the values of the percentage reduction in water evaporation for the different cases.

7. It will be seen that the suppression of evaporation to the extent of 60 per cent and above persisted for a number of days in the case of octadecyl alcohol and ether and there was no reduction in evaporation after 4 days in the case of cetyl alcohol. There was a short spell of rain on the night of 9 February 1964 which seems to have had some adverse effect on the films.

TABLE 2

Date	Pan No. 63 120 drops of octadecyl alcohol and ether solution				Pan No. 65 80 drops of octadecyl alcohol and ether solution				Pan No. 61 80 drops of cetyl alcohol solution			
	(a)	Temp. (°C)	(b)	Temp. (°C)	(a)	Temp. (°C)	(b)	Temp. (°C)	(a)	Temp. (°C)	(b)	Temp. (°C)
February 1964												
6	80	1·1	80	9·4	55	1·7	65	9·4	48	1·1	61	10·0
7	78	1·1	75	10·0	72	1·7	55	10·6	69	1·1	60	10·6
8	78	2·8	70	10·6	69	2·8	69	11·1	58	2·2	57	11·1
9	70	5·6	70	12·2	63	5·6	65	12·2	56	5·6	60	11·7
10	Rained at night of 9-2-64 and morning of 10-2-64. 1·5 mm of rain recorded. Fresh observations were taken.											
11	65	5·0	67	13·3	3	5·0	10	13·3	—	4·4	6	12·2
12	55	4·4	55	12·2	16	4·4	21	12·2	—	3·9	5	11·7
13	32	3·9	—	10·0	20	3·9	—	10·0	—	3·3	—	10·6

(a) Percentage reduction in water evaporation from 1030 hrs of the day to 1030 hrs of the following day
(b) Percentage reduction in water evaporation from 1630 hrs of the day to 1630 hrs of the following day

TABLE 3

	Pan No. 61 80 drops				Pan No. 65 40 drops			
	(a)	Temp. (°C)	(b)	Temp. (°C)	(a)	Temp. (°C)	(b)	Temp. (°C)
26-7-63	—	—	62	30·6	—	—	60	31·1
27-7-63	33	22·7	70	27·2	33	23·3	51	27·2
28-7-63	32	21·1	9	21·7	25	21·1	7	21·7
1-8-63	0	20·0	0	20·0	0	23·9	0	23·9
2-8-63	0	20·0	0	20·0	0	23·3	0	23·3

(a) Percentage reduction in water evaporation from 1030 hrs of the day to 1030 hrs of the following day
(b) Percentage reduction in water evaporation from 1630 hrs of the day to 1630 hrs of the following day

8. Similar experiments made in the months of June and July 1963 with the same compounds in solution were interesting. One of these experiments done in July is as follows—

At 1100 hrs of 26 July 1963, 80 and 40 drops of the solution were dropped in pan numbers 61 and 65 respectively. The monomolecular film in this case remained for 3 days till they were completely washed away by rain on 29th as can be seen from Table 3.

9. It will be seen from Fig. 3 which shows the record of Intensity Recorder on 29 July 1963 that the highest intensity of 68·6 mm (2.7″) per hr lasted for a longer period. The total rainfall of this day was 53·1 mm (2.13″). In this case it seems the rainfall was so heavy that the entire film was completely destroyed and there was no reappearance of the film.

10. Similar experiments were conducted three times in summer months of June

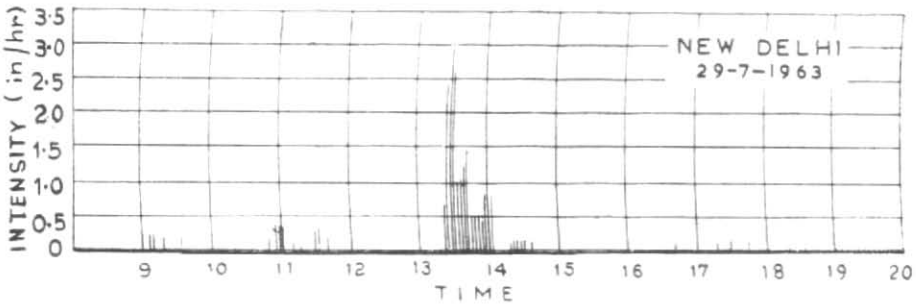

Fig. 3

and July 1963 (29 June to 1 July, 5 to 7 July and 26 to 28 July), and it was found that although the range of suppression of evaporation was within the limit of 70 to 54 per cent on the first day and 26 to 7 per cent on the third day with the temperature of water at approximately 26·5 to 21·6°C, the power of suppression of evaporation of the monolayer ceased completely after 3 or 4 days in all cases.

11. It appears from these experiments that the suppression of evaporation due to mono-molecular layers of long chain ethers and alcohols is very effective at comparatively low air and water temperatures when not only the value of the percentage reduction in water evaporation is very high but the period for which this suppression is maintained with treatment of extremely small quantity of the solution is also long. Particular attention is drawn to this dependence on the temperature of the water surface even when the initial monomolecular layer is formed from solution in petroleum ether.

12. It will be seen from the experiment of February 1964 that the short spell of rain on 9th has been able to wash away completely the films produced by cetyl alcohol which did not again produce any suppression of evaporation after rains, whereas films of glycol octadecyl alcohol and ether regained its power of suppression of evaporation. From these experiments, it may be inferred that monolayers of glycol octadecyl alcohol and ether are more efficacious and are more stable on water surfaces than for example, cetyl alcohol.

13. The compounds octadecyl alcohol and glycol mono-octadecyl ether used in these experiments were obtained from National Chemical Laboratory, Poona through the kind courtesy of Dr. A. B. Biswas. I am thankful to the Director General of Observatories for the kind interest he has taken in this work.

BIBLIOGRAPHY

Price 1960 Water Conservation bibliography. Prices (Bromborough) Ltd., Bromborough Pool, Chashire, England. Tech. Pub., 7.