

EVAPORATION OF WATER IN ASSOCIATION WITH DIFFERENT FORMS OF CARBON

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Evaporation of water in association with graphite, charcoal powder and lamp black in different states—external coating, internal coating and in the spread-over-state was studied. Lamp black in the spread-over-state has been observed as the best accelerator to evaporation when compared to other two under similar conditions.

Heat absorbed by a body when exposed to solar radiation depends upon the geographic position of its site (latitude), position of the sun, weather conditions¹ and the nature of the body. Thus at any place for better absorption of solar radiation the scope lies in the selection of better heat absorbing bodies. Black bodies, in general, have been found to be the most efficient. Accordingly, heat absorbing components in most of the machines are either made of black material or their surfaces are painted black. Majority of black materials or paints contain lamp black as the main constituent². Since graphite, wood charcoal and lamp black are more or less impure forms of carbon and known to have somewhat similar crystalline structure³, a study was planned to assess the influence exerted by these forms in the evaporation of water.

EXPERIMENTAL

The procedure used by Ramacharlu⁴ for studying the evaporation of water from the heated soils was followed broadly. Purified samples of graphite, charcoal powder and lamp black were sieved separately to obtain fractions of uniform particle size ranging between 0.074—0.17 mm to maintain same texture of the materials to start with. Equal weights (0.25 g) of these fractions intimately mixed with 2 ml of a clear synthetic varnish were applied internally or externally on the base of a glass petri dish. In third set of experiments, the fractions were used in the spread-over-state on the surface of water in a dish. Experiments were done on different days. In each experiment flat bottom glass petri dishes of equal dimensions (dia. 70 mm and wall height 15 mm) with internal coatings in Set I, external coatings in Set II and in spread-over-state in Set III of the 3 forms of carbon, were weighed with 50 ml of distilled water and then exposed in the sun for 3 hours. The total evaporation from each dish was determined from the loss in weight and calculated on percentage basis. During each experiment the intensity of solar radiation in the vicinity of experiment was also measured on half hourly basis with the help of a pyranometer 'Star 628' and the integrated heat input on the surface of each dish in the experimental duration was calculated by an equation similar to one used by Anand and Jayaraman⁵.

RESULTS AND DISCUSSION

The total evaporation and the rate of evaporation per K cal of heat input for 3 hours of different experiments are given in Table 1. Also the average rate of evaporation effected by the three forms in different states are presented as histograms (Fig. 1) with respect to graphite (expressed as 100%).

TABLE 1

TOTAL EVAPORATION (A) AND THE RATE OF EVAPORATION PER K CAL OF HEAT INPUT (B) ON PERCENTAGE BASIS OF WATER IN ASSOCIATION WITH DIFFERENT FORMS OF CARBON IN DIFFERENT STATES

Expt. No.	State	Heat input (K Cal)	Control		Graphite		Charcoal		Lamp black	
			(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
1.	Internal coating	9.6	56.23	5.86	67.00	6.98	73.00	7.60	74.00	7.71
2.	"	8.4	48.00	5.71	59.30	7.06	65.40	7.79	67.00	8.00
3.	"	9.0	52.00	5.78	62.80	6.98	69.80	7.76	72.40	8.04
4.	External coating	12.2	64.40	5.28	80.10	6.57	83.80	6.87	85.00	6.97
5.	"	5.2	52.40	10.08	63.00	12.12	66.30	12.75	68.50	13.17
6.	"	8.6	63.40	7.37	75.80	8.81	80.00	9.30	82.30	9.57
7.	Spread-over-state	11.8	—	—	70.30	5.96	80.30	6.81	82.60	7.00
8.	"	11.0	—	—	65.00	5.91	76.00	6.91	78.00	7.09
9.	"	13.4	—	—	79.00	5.90	91.00	6.79	92.40	6.90

A comparative study of the data presented in Table 1 and histograms in Fig. 1 shows that :

1. All forms of carbon in different states accelerate the evaporation by 18% to 36% as compared to the control, i.e. distilled water as such.
2. Lamp black as external coating causes higher evaporation than graphite and charcoal by 8% and 5% respectively.

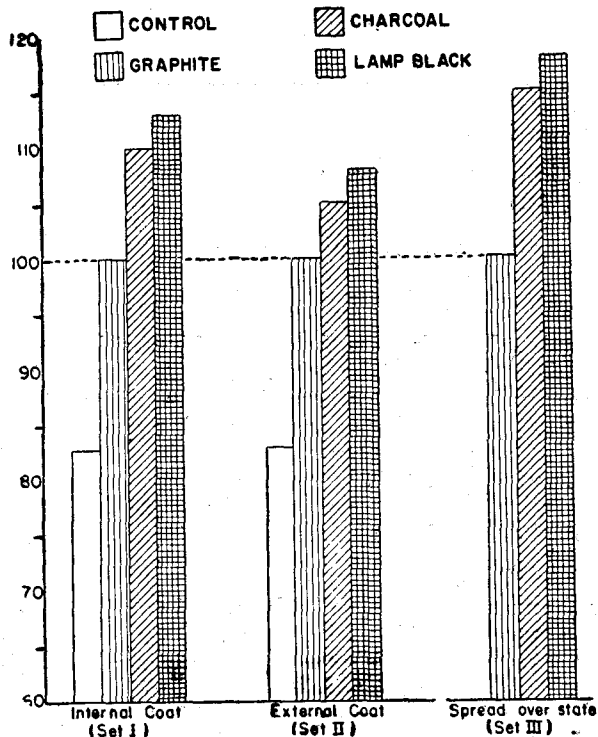


Fig. 1—Average rate of evaporation ($K \text{ cal}^{-1}$) of different forms of carbon in different states with respect to graphite expressed as 100%.

approximation to ideal black body and mainly responsible for accelerating evaporation to the maximum in each set of experiments. Further, in experiments of Set III, it has been observed that larger portion of graphite, comparatively lesser of charcoal and negligible quantity of lamp black settled on the bottom of their respective dishes. The hexagonal planar structures described as "graphite platelets" with larger interlayer spacing than graphite⁹ of the lamp black particulates; and its lower density¹⁰ (1.84) than graphite (2.3) appear to keep it in the spread-over-state on the surface of water. In charcoal its graphite structure is not very well developed¹¹ with the result that only part of it remains in the spread state in spite of its lowest density (1.45). Lamp black when used in the spread-over-state appears to absorb maximum quantity of radiant energy and emits in close vicinity of the surface of the liquid. Hence the highest rate of evaporation as compared to graphite and charcoal in the same state has been observed. However, its quantitative efficiency in the spread-over-state over the other states remains to be studied further though qualitatively it appears to be better.

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3. Lamp black as internal coating causes much higher evaporation than graphite and charcoal by 13% and 10% respectively.
4. Lamp black in the spread-over-state increases evaporation by 18% and 15% when compared to graphite and charcoal in the same state respectively.
5. There appears to be a slight inconsistency between the heat input and average rate of evaporation (Expt. No. 5 & 8) which is attributed to the high wind velocity on the days of experiments.

Evaporation is known to be controlled by (1) nature of the liquid, (2) its surface area, (3) removal of air in contact with the liquid, (4) relative humidity, (5) pressure prevailing on its surface and (6) temperature of the liquid. By evaporating equal volumes of water in equal size dishes and exposing them in a limited area of a terrace the effects of factors 1-3 in each individual experiment were kept almost identical. Factors 4 and 5 were also similar over the dishes. However, factor-6 (temperature of the liquid) was allowed to be influenced by the three forms of carbon in different states and consequently to effect the total evaporation.

It has been reported by White⁶ that an ideal black body (not yet discovered) would reflect no energy but emit all of it. Lamp black with its highest emissivity and lowest reflectivity⁷ appears to be a good