COMPARISON OF RAINGAUGE EVAPORATION SUPPRESSANTS

D. L. Murray*

ABSTRACT

The efficiencies of two evaporation suppressants for protecting raingauge catch are compared. Results indicate that kerosene is inferior to light machine oil when high-precision data are required. Approximately 50 g of oil gave satisfactory evaporation suppression.

INTRODUCTION

Evaporation of precipitation catch has been recognized as a source of systematic error in rain gauging for many years (Corbett, 1967). Frequent readings, construction, and siting specifications for a standard raingauge are intended, in part, to eliminate this bias.

In remote areas, however, the reading frequency will be low, and where snow occurs the construction and siting of a gauge may be far from standard. In these conditions it has become common practice to add to the collecting vessel a small quantity of kerosene or oil to act as an evaporation suppressant. Hamilton and Andrews (1953), working in southern California, considered that 4 mm of oil would be adequate protection for rain catch even in a gauge without a funnel.

AIMS

This study compares the performance of kerosene and BPWM2 oil (specific gravity 0.845) as evaporation suppressants in raingauges. No attempt is made to relate evaporation rate to its causative factors. The need for the study arose during an investigation into the effects of exposure on gauge catch, in which high-precision data are obtained by weighing gauge contents. Since separation of evaporation suppressant from the water is not feasible it must be assumed that there are no losses of the suppressant between readings. Low-precision volumetric measurements indicated that this was probably invalid when kerosene was used.

* Department of Geography, University of Otago, Dunedin.

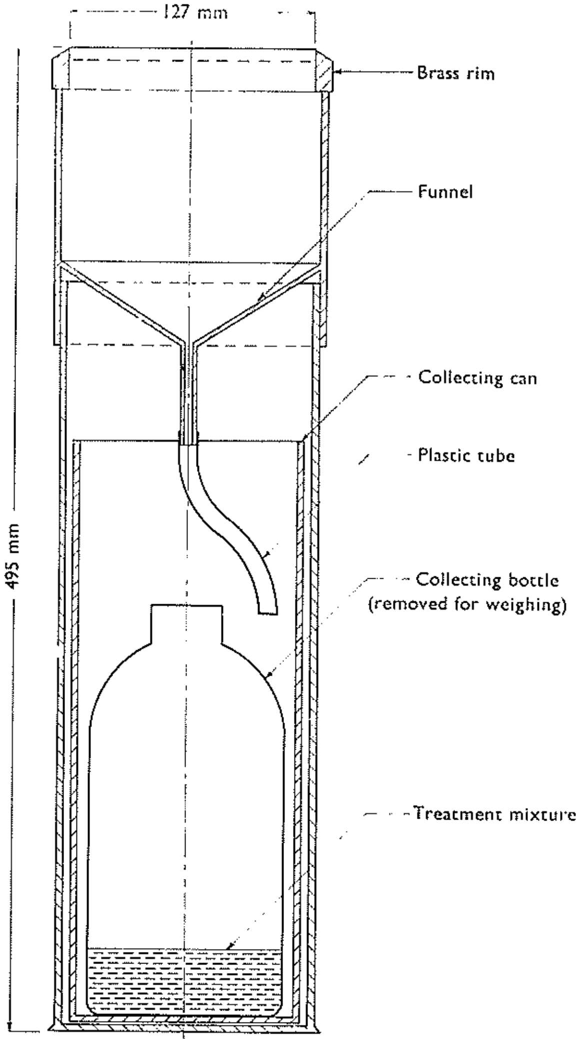

FIG. 1 — Cross section of raingauge and collector as used in trials.

DESIGN

Details of the four trials and treatments are shown in Table 1. Each trial lasted approximately 30 days, the whole study being conducted in the climate station of the Department of Geography, University of Otago, between November 1971 and April 1972.

TABLE 1 — Details of evaporation suppressant trials.

Trial	*No. of gauges*	*Treatment*	*Method of analysis*
1	4	50 g oil	Student's *t* test
	4	50 g kerosene	
2	6	50 g kerosene	Student's *t* test
	6	50 g kerosene, 322 g water	
3	3	50 g kerosene	analysis of
	3	50 g kerosene, 322 g water	variance, and
	3	50 g oil, 322 g water	Duncan's multiple
	3	322 g water	range test
4	2	0 g oil, 322 g water	analysis of
	2	25 g oil, 322 g water	variance, and
	2	50 g oil, 322 g water	Duncan's multiple
	2	75 g oil, 322 g water	range test
	2	100 g oil, 322 g water	
	2	125 g oil, 322 g water	

Note: 100 g water is approximately 8 mm in a 127-mm diameter raingauge.

The 12 raingauges were set up in a grid pattern in an enclosed level area of short-clipped grass. They differ from the standard Meteorological Office gauge in three respects: construction is of galvanized sheet metal, the body is cylindrical rather than conical, and the funnel drains through a flexible plastic tube into a collecting bottle (Fig. 1). This tube was arranged to prevent rainfall contaminating treatments during the trials.

The treatments were applied to plastic collecting bottles which were weighed every two to four days and replaced at random in the gauges. All measurements were made on a balance whose smallest division is 0.1 g and whose coefficient of variation in registering 100 g is 0.04 percent.

Analyses were made only on the total losses from each treatment over the period of trial.

RESULTS

In the first trial comparing the two suppressants, there was a mean loss of 0.1 g of oil, and 3.2 g of kerosene. Tests at the 1 percent significance level show the mean loss of kerosene is greater than the mean loss of oil. A further test of the oil treatment showed that its losses were not significantly different from zero.

The second trial measured losses from kerosene and losses from a kerosene and water mixture. Over the period the mean values were 4.8 g and 5.9 g respectively. While the statistical test shows a significant difference between these means, it is not possible to decide definitely whether the extra evaporation was from the water or the kerosene in the mixture. If the evaporation of kerosene is assumed to be the same for both treatments then a significant loss of water from the mixture has occurred through the kerosene film.

The main comparison of kerosene and oil as evaporation suppressants was made in the third trial. The foregoing results showed the need for a treatment with kerosene only. To give an indication of the absolute efficiencies a treatment with water but no additives was also included. Results are shown in Table 2. Analysis of variance reveals significant differences between treatment means, and Duncan's multiple range test shows that all comparisons between treatment means differ significantly at the 1-percent level except the kerosene, and the kerosene plus water mixture. The mean loss of 0.2 g from the oil and water mixture was not significantly different from zero.

The aim of the fourth trial was to obtain data which would permit specification of the quantity of oil required for efficient evaporation suppression. While analysis of the variance of the results (Table 3) leads to rejection of the null hypothesis that all treatment means are equal, the specific tests show only the zero oil treatment to be different. All other treatments have effectively equal losses when compared at the 1-percent significance level.

TABLE 2 — Loss in weight of the four treatments in Trial 3 over a period of 30 days.

Treatment	*Loss in weight (grams)*			
	Replicates			*Mean*
50 g kerosene	5.0	4.9	4.6	4.8
50 g kerosene, 322 g water	6.2	5.0	4.8	5.3
50 g oil, 322 g water	0.1	0.3	0.2	0.2
322 g water	14.9	14.6	15.7	15.1

TABLE 3 — Loss in weight of water with varying amounts of oil added over a period of 30 days (Trial 4).

Treatment	*Loss of weight (grams)*		
	Replicates		*Mean*
0 g oil, 322 g water	14.5	11.5	13.0
25 g oil, 322 g water	1.3	1.3	1.3
50 g oil, 322 g water	1.0	0.9	1.0
75 g oil, 322 g water	0.9	1.1	1.0
100 g oil, 322 g water	1.0	1.3	1.2
125 g oil, 322 g water	1.0	1.0	1.0

DISCUSSION

The measured evaporation of kerosene is, at first glance, not serious since sufficient kerosene could be added to a gauge to maintain a protective film over the catch between readings.

The differences in evaporation of kerosene alone and a kerosene and water mixture are more relevant to experimental rain gauging than routine field measurements. In the latter case, any losses of kerosene could be accounted for as the measurement is normally made volumetrically, permitting approximate separation of the two liquids. Small losses of water would remain undetected, though the limited data from this study suggest that these losses would probably be within the confidence limits of field measurements.

In experiments where higher-precision data are sought by using gravimetric methods, separation of kerosene and water is not feasible and so loss of kerosene would lead to bias in measurements. Estimates of this loss, based on variations of causative factors such as temperature and humidity, would be fraught with uncertainty and unlikely to increase confidence in the final result. This difficulty is demonstrated by the results of the third trial. Approximately 5 percent of the water evaporated when there was no additive, but the addition of 50 g of oil reduces this loss to zero. The addition of 50 g of kerosene, however, leads to an uncertain result: some losses occurred, but it cannot be stated whether the losses are entirely kerosene, or partly water. If the evaporation of kerosene from the mixture is assumed to be the same as that from the kerosene alone, then kerosene may also be considered an efficient evaporation suppressant. Without the kerosene-only treatment, even this unsubstantiated conclusion could not be reached.

In the final trial all quantities of oil were equally efficient. The disturbing result is that the mean loss from the oil-plus-water treatments is about five times greater than in the previous trial, while the evaporation from water alone is slightly less. This result cannot be explained in terms of the data collected in this study. It seems possible, however, that it is related to time and frequency of reading as well as environmental variables. When a collecting bottle is placed in a gauge, the gauge atmosphere will eventually become saturated with vapour from the treatment liquids. Each time the gauge is opened for weighing, the vapour will disperse and a small loss from the system will occur. This hypothesis will be tested with a larger sample over several summer months.

Although these trials have shown that small losses may occur when BPWM2 oil is used, more confidence can be placed on its effects than on those of kerosene. If absolute control of evaporation is sought then a compromise must be drawn between the presumably more efficient highly viscous oils, and the more easily handled light oils.

CONCLUSIONS

The results of tests of two materials, kerosene and BPWM2 oil, as evaporation suppressants lead to two main conclusions.

Kerosene is generally unsatisfactory, since its own evaporation rate is appreciable. In high-precision gravimetric measurements the suppressant and gauge catch cannot be separated, while in low-precision volumetric measurements the possibility of evaporation of an unknown quantity of water remains.

The BPWM2 oil is a preferable, though still imperfect, evaporation suppressant. Its own evaporation rate was shown to be negligible, and when added to water only very small losses occurred from the mixture over a period of 30 days. These losses would barely be detectable with standard raingauge measuring cylinders. Different quantities of oil appeared equally efficient, and results indicate that 50 g or approximately 5 mm in a 127-mm (5-inch) diameter raingauge would suffice.

ACKNOWLEDGMENT

Finance for the project of which this study is part, was obtained from the University Grants Committee Research Committee.

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