

### Water Balance and Evaporation Studies

PENMAN<sup>1</sup> has put forward an elegant expression for evaporation  $E$  for various types of surfaces with a wide range of climatic regions taking into consideration the energy balance and the aerodynamic factors. The equation is:

$$E = \frac{H + Ea \frac{\gamma}{\Delta}}{1 + \frac{\gamma}{\Delta}}, \quad H = R_c(1 - r) - R_B$$

where  $R_c$  is incoming radiation,  $r$  is the reflexion coefficient for a vegetative surface,  $R_B$  is out-going long-wave radiation calculated from:

$$R_B = \sigma T_a^4 \{0.56 - 0.09\sqrt{e_a}\} (1 - \alpha m)$$

$\sigma$  is the Stefan Boltzmann constant,  $e_a$  is the actual vapour pressure and  $\alpha m$  is the fraction of sky covered by clouds in tenths.

$Ea$  = aerodynamic term  $0.0105(0.5 + 0.01 U)$  ( $e_a - e_a$ )  
 $U$  = miles per day at 2 m height,  $e_a$  is the saturation vapour pressure of air at temperature  $T_a$ .  $\gamma$  is the psychrometric constant;  $\Delta$  is the gradient of saturation vapour pressure against temperature curve at air temperature.

The first and last terms in the equation are positive, and contribute positively to evaporation. The term  $R_B$  contributes negatively, which means there is condensation taking place due to long-wave radiation. This term assumes a significant role during the night when the incoming radiation is cut off. The evaporation term then consists of two terms, one of which is negative and hence there will in effect be a condensation process taking place. If the aerodynamic term remains unchanged during the night, it contributes to the evaporation a magnitude which may result in the total being negative or positive.

During the winter months on clear-sky days systematic measurements have been made to find the surface soil moisture over Poona. It is found that there is a daily variation of soil moisture, reaching a minimum at the maximum epoch of temperature and a maximum at the minimum temperature epoch. Various explanations have been offered for this variation of moisture. One such explanation is based on the fact that near the surface soil there is a reversal of the vapour pressure gradient at night resulting in invisible condensation.

It appears from Penman's equation that both during day and night there is a process of condensation taking place near the surface of the Earth which in the day is completely outbalanced by the incoming short-wave radiation, resulting in a net evaporation. In the absence of sunlight long-wave radiation plays a predominant part in condensation of water vapour on the soil. This explains also the different moisture-holding capacity of soils under identical meteorological conditions.

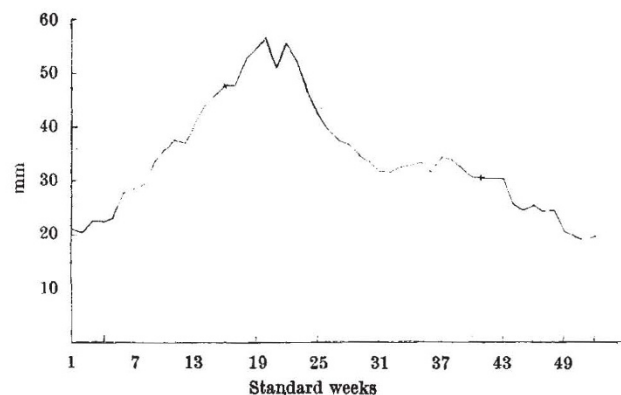


Fig. 1. Evaporation from an open water surface at Poona, estimated according to Penman (ref. 1)

In arid and semi-arid zones this factor is important for the study of water balance in relation to crop development in winter and may explain the large vegetation growth during these months when there is no rainfall. A study of the various meteorological factors in contributing to evaporation over Poona using Penman's equation reveals that on an average the annual evaporation is mainly contributed by the term containing the incoming radiation, the sum of other two terms over 52 weeks having equal positive and negative values. The study of evaporation over Poona week by week using Penman's equation shows that about the 16th week and the 40th week, reckoned from January 1 (corresponding to the middle of April and the end of September), the net contribution for evaporation by the aerodynamic term and long-wave radiation term is practically zero. The variation of evaporation with time week by week as calculated by Penman's equation is shown in Fig. 1 and agrees reasonably well with observed open pan evaporimeter values. This investigation will be pursued for all the agrometeorological and crop weather observatories in India where all the parameters required for the calculation of evaporation by Penman's equation are available for more than 10 or 15 years.

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<sup>1</sup> Penman, H. L., *Proc. Roy. Soc., A*, **183**, 120 (1948).

## CHEMISTRY

### Diperoxodiethylenetriamminechromium(IV) 1-hydrate: a New Chromium(IV) Peroxo Compound

DIPEROXOTRIAMMINECHROMIUM(IV),  $\text{Cr}(\text{NH}_3)_3(\text{O}_2)_2$ , one of the more stable chromium compounds containing peroxo groups<sup>1</sup>, has been known for many years<sup>2</sup>, and recently the X-ray crystal structures of this and other chromium peroxo compounds have been reported<sup>1,3-8</sup>.

We have now prepared an analogous triamine containing the tridentate ligand diethylenetriamine ( $\text{NH}_2(\text{CH}_2)_2\text{NH}_2 = \text{dien}$ ) which crystallizes from water as the 1-hydrate,  $[\text{Cr}(\text{dien})(\text{O}_2)_2] \cdot \text{H}_2\text{O}$ . The compound was prepared by the dropwise addition of 15 ml. of 30 per cent hydrogen peroxide to a stirred solution of 5 g of sodium dichromate 2-hydrate, 10 ml. of water and 6 ml. of dien at 5°-10°. Effervescence occurred and an orange-brown coloured solution developed due to the formation of the  $\text{Cr}(\text{O}_2)_4^{-3}$  anion. The solution was kept at 15° for about two days, the colour slowly changing to lime green and olive-green crystals of  $[\text{Cr}(\text{dien})(\text{O}_2)_2] \cdot \text{H}_2\text{O}$  (calc.: Cr, 21.92; C, 20.26; H, 6.37; N, 17.72. Found: Cr, 21.95; C, 20.51; H, 6.34; N, 17.80) were formed. These were collected by filtration and washed with methanol.

The oxidizing power was measured by determining the amount of iodine liberated by the solid from acidified potassium iodide and also by treating the solid with excess permanganate solution, adding excess iron(II) ion and back-titrating with permanganate. The mean of three determinations gave a value of 2.48 moles of iodine per mole of diperoxo complex (theory = 2.50) and 2.95 oxidation equivalents of permanganate per mole of complex (theory = 3.00), supporting the chromium(IV) diperoxo assignment.

The diperoxo complex is soluble in water to give a lime-green solution ( $\lambda_{\text{max}}$  610  $\text{m}\mu$  ( $\epsilon = 38.6 \text{ M}^{-1} \text{ cm}^{-1}$ ), 520 (41.5), 382 (460), 250 (5,400);  $\lambda_{\text{min}}$  570 (38.5), 485 (38.8), 355 (415), 235 (4,880)) and both the aqueous solution and the solid appear to be stable for at least 24 h at room temperature in laboratory light, although both decompose when warmed. The solid explodes when heated to 109°-110° (heating rate = 2°/min). We have found that