SHORTER CONTRIBUTION

The relationship between the concentration of nitrate- and ammonia-nitrogen in precipitation

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Although it is fairly well established that particulate and gaseous compounds contribute to the nitrogen content of rainwater, the origin of nitrate- and ammonia-nitrogen is less well understood.

Several workers, including KASNER (1926), HUTCHINSON (1944). and ÅNGSTRÖM & HÖGBERG (1952), have noted the almost constant ratio of about 1:2 in which nitrate- and ammonia-nitrogen appear in the precipitation in temperate regions. On the basis of this it has been suggested that the production of nitrate- and ammonia-nitrogen is intimately related (HUTCHINSON; ÅNGSTRÖM & HÖGBERG); probably arising from a photochemical process. However, the results of chemical analyses of precipitation reported in the literature do not always confirm the existence of this ratio (see, for example, VIRTANEN, 1952; and GAMBELL & FISHER, 1964).

Below are presented the results for the ammonia- and nitrite- and nitrate-nitrogen content of the precipitation at Malham Tarn Field Centre, Settle, Yorkshire, England, for the period Oct. 1961–Oct. 1962. The collection apparatus consisted of a large polythene bottle, fitted with a polythene funnel. The bottle was changed monthly and toluene used as a sterilant. Ammonia-nitrogen was determined colorimetrically by direct Nesslerisation (Standard Methods for the Examination of Water and Wastewater, 1960). After the conversion of nitrite to nitrate using permanganate, nitrate-nitrogen was determined colorimetrically by the phenoldisulphonic acid method (Standard Methods etc. ...) except that potassium hydroxide was used for colour development (HORA & WEBBER, 1960).

Appreciable amounts of ammonia-nitrogen are brought down in the precipitation and there is a highly significant ($r = 0.76^{***}$) inverse relationship between the concentration of ammonia-nitrogen in the precipitation and the amount of precipitation which falls in any one month. There is a similar relationship ($r = 0.87^{***}$) between nitrite- and nitrate-nitrogen and the monthly amount of precipitation. These observations confirm the findings of SCHARRER & FAST (1951) and ZUBER (1963), although the recognition of this relationship is rarely encountered in the literature.

The concentration of nitrite- and nitrate-nitrogen is always lower than that of ammonia-nitrogen and there is a fairly constant ratio of 1:2.2 for these two constituents in the precipitation ($r = 0.85^{***}$; nitrite- and nitrate-nitrogen $= 0.42$ ammonia-nitrogen $+ 0.03$).

The nitrite-nitrogen content of precipitation is thought to constitute approximately 10 per

TABLE 1. *Ammonia- and nitrite- and nitrate-nitrogen in the precipitation at Malham Tarn Field Centre.*

Oct. 1961–Oct. 1962.

Month	Precipitation inches	Ammonia-nitrogen mg/l	Nitrite- and nitrate-nitrogen mg/l
Oct. 1961	6.92	0.75	0.26
Nov.	3.54	0.89	0.39
Dec.	5.14	0.56	0.33
Jan. 1962	7.74	0.62	0.25
Feb.	5.28	0.41	0.20
Mar.	1.62	0.99	0.50
Apr.	5.64	0.62	0.26
May	4.42	0.76	0.36
June	1.80	0.87	0.44
July	3.03	0.86	0.36
Aug.	7.58	0.53	0.27
Sept.	5.39	0.59	0.32
Oct.	2.67	0.87	0.39

cent that of nitrate-nitrogen (ERIKSSON, 1952). When allowance, using this value, is made for the content of nitrite-nitrogen, a value of 1:2.4 is obtained for the ratio of nitrate- to ammonia-nitrogen in the precipitation at Malham Tarn Field Centre.

These results for the relationship of nitrate- and ammonia-nitrogen in the precipitation are similar to those presented by KASNER (1926), HUTCHINSON (1944), ÅNGSTRÖM & HÖGBERG (1952), DROVER & BARRETT-LENNARD (1953), and WEINMANN (1955) but are discordant with the findings of many workers.

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BOOK REVIEW

Cloud Structure and Distributions over the Tropical Pacific Ocean. By J. S. Malkus and H. Riehl, Univ. of California Press, Berkeley and Los Angeles, 1964 (229 pp.), $7.50.

In spite of its (handsome) appearance this book is not a text, but rather a progress report; it contains substantially the same material previously issued as a Contract Report from the Woods Hole Oceanographic Institution.

In the summer of 1957 time-lapse ciné photographs were made of the sky during three trans-Pacific flights, at the initiative of the authors, and in this report these well-known leaders in the study of tropical weather discuss in some detail what can be learned from them about the organisation and working of tropical clouds and cloud systems. Such simple photographic reconnaissance, which surely could be realised over most of the globe, is shown to be a most useful and rewarding technique.

The principal conclusions are, first, that here as elsewhere, amongst endless complication there is evidence of strong organisation, so that one must suspect the existence of some simple keys with which what may at first seem chaos could readily be resolved. Secondly, there is a very close relation between the small-scale cloud development and the synoptic-scale structure of the atmosphere. As is recognised in the conclusions, this association could have been better confirmed and exploited had there been available more soundings, perhaps best of all drop-sondes released by the aircraft. As it is, it is clear that a "state of sky" code can be sufficient to summarise cloud observations, and the authors present one of their own devising.

Amongst a number of criticisms listed by the reviewer, he now thinks only one worth mentioning, that perhaps too often the writers imply that the large-scale circulations control the clouds, rather than vice versa, or that they should be regarded as inseparable. The detailed description and illustration are full of interest for the diligent reader, and it is no adverse criticism to say that the final impression is that such work must be done again, and again, with additional facilities, and not only in the Pacific.

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