

the amount of gypsum which should be applied to the water or to the land to prevent high alkalinity, serious soil impermeability, and the deficiencies of the calcium and magnesium required for normal growth. Knowledge of the existence of the alkali problem, both present and future, is indicated by the inclusion, in the paper by Dorfman, Revelle, and Thomas, of a discussion of the "sodium hazards". There were no statistics to indicate the magnitude of the problem represented by the composition of the groundwaters or of the proportion of the land which is now so high in sodium that leaching is too slow to be fully effective. No mention is made of the use of gypsum as a corrective.

On the basis of the old groundwater analyses, which the writer was able to find in Pakistan at the time of his three-month visit in 1952-1953, the problem of excess sodium and high alkalinity in soils and groundwaters impressed him as being serious and deserving of careful attention. Since that visit, Hausenbuiller, *et al* [6, pp. 356-364] were similarly impressed and recommended applications of gypsum where needed. The writer recalls experimental data from the vicinity of Montgomery which demonstrated outstanding yield benefits from the use of gypsum. No practical substitute for the use of gypsum on high sodium alkali lands is known.

Ghulam Mohammad has reviewed [5, pp. 357-403], the now-available analyses of groundwaters of the Indus Plain. Even on the questionable assumption that 1.25 me./l of residual sodium carbonate may be safe (*see*, later discussion), the data show that the less saline waters are commonly so high in sodium and/or bicarbonate as to make their use hazardous unless they are mixed with canal water or treated with gypsum.

Private interests will undoubtedly avail themselves of the groundwaters of Pakistan by pumping only so long as the qualities of these waters permit profitable crops. When there is no longer a profit, the wells will be abandoned, after which the watertables will again rise. It seems doubtful at this stage that private funds will be available for the construction of the drainage system which should have been established when the distributary canals were constructed. The cost of a country-wide drainage system is so great that it seems doubtful that public agencies can now undertake it.

On-Farm Drainage

It was for the foregoing reason, and the foregoing reason only, that the writer in his FAO report [3] suggested a type of drainage system which he believed the farmers themselves could install and maintain. Such a system, although not ideal, may be the only recourse possible, now or in future, in many areas of Pakistan.