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Short communication

Water diffusion through pottery discs of varying porosity

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Abstract

Pottery sheets of disparate diffusion rates were produced by altering the particle size distribution of sand (500 to 2000 μm diameter) in the clay-sand mix and by mixing organic matter (sawdust) with clay in variable proportions (1 to 15% by weight). It was used for evaluating the nature of interrelationships between water diffusion rates and the fabrication parameters. Results show that water diffusion is more consistent for the organic matter-mixed pottery samples than the sand-mixed ones. Uniform porosities of organic matter-mixed pottery discs, as evidenced by optical micrographs, further exemplify that. Pots/pottery sheets produced through this process can thus be used for controlling water release in pitcher irrigation of tree saplings.

Key words: controlled release, diffusion, pitcher irrigation, pottery sheets

Traditionally, the villagers place water-filled pots or pitchers in the farm fields for irrigation during the summer season (Mondal, 1992). The water diffusing through the pottery into the root zone is absorbed by the plants, and to a certain extent, this is a method for controlled release of water (Das, 1983). Nevertheless, the ordinary pots—those available in the market, typically manufactured for cooking purposes and/or for storing water—may lead to either sub-optimal or supra-optimal diffusion rates. This is because in the conventional pottery production technique, clay is mixed with about 15% by weight of fine sand and then it is shaped as required and finally baked over a fire. The whole process is probably aimed at the production of pottery for domestic uses. Furthermore, and as far as it is known, no systematic study for assessing the porosity requirements of the pottery materials used for pitcher irrigation has been conducted previously. Therefore, attempts were made to control the formation of pores in the pottery sheets by varying the particle size distribution of sand, which is mixed with clay, and by altering the relative proportion of organic matter in the substrate used for production. The specific purpose of the study was to evaluate the nature of interrelationships between rate of diffusion of water and the pottery fabrication parameters.

To produce the experimental pottery sheets, clay was first wet-sieved through a fine sieve to remove the coarse particles and dried. Sand having 500, 1000, 1500 and 2000 μm diameter were then added to the samples (15% by weight) and mixed thoroughly (separately for each textural class). Another set of samples, with varying amounts of sawdust (3, 5, 10 and 15% by weight of clay) also was prepared. The samples were shaped in the form of circular discs and baked over a fire at about 1000 to 1100°C for 50 h. The baked discs were of 15 cm diameter and 5 mm thick.

The experimental setup used for diffusion studies consisted of a graduated transparent bucket with its bottom removed and the pottery sheets fixed at the bottom and the interface sealed water-tight. The water diffused through the pottery sheets was measured at intervals of 24 h and in replicates of 10 each.

Data presented in Fig. 1 clearly show that the rate of diffusion increased as the particle size of sand increased.

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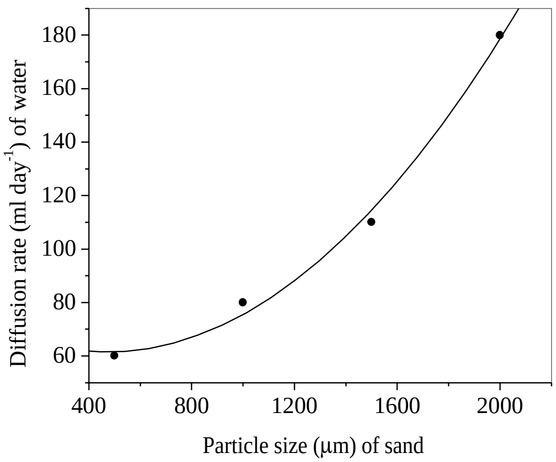

Figure 1. Effect of particle size of sand on the diffusion rate of water (data for the above plots are averages of 10 samples each)

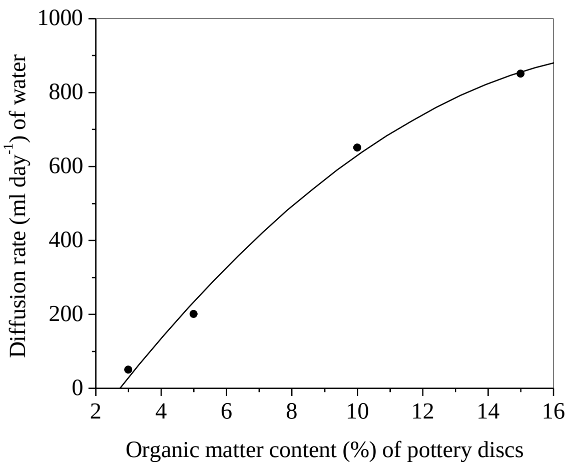

Figure 2. Effect of organic matter content of pottery disc on the diffusion rate of water (data for the above plots are averages of 10 samples each)

Likewise, the rate of diffusion increased with increasing percentage of the organic matter (Fig. 2). As expected, the regression analysis indicated strong interrelationships between diffusion rates and particle size distribution (r^2 = 0.92) and with the relative proportion of organic matter in the clay-mix (r^2 = 0.97).

Optical micrographs (Figs. 3 to 5) of the samples containing fine sand (grain size $\leq$ 500 μm), coarse sand (1000 to 1500 μm) and organic matter (10% by weight of clay) further illustrate the nature of these interrelationships.

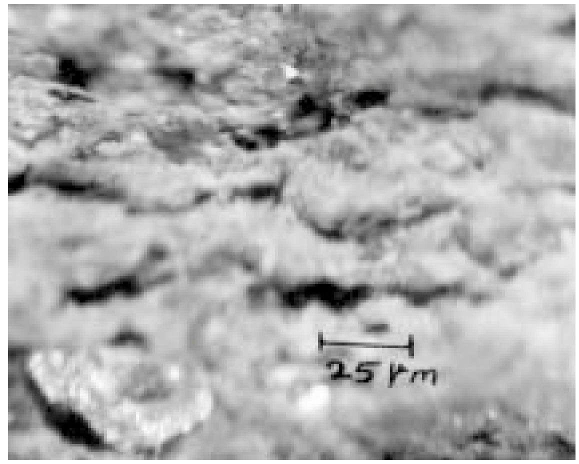

Figure 3. Optical micrograph of the pottery disc containing fine sand ($\leq$ 500 μm diameter)

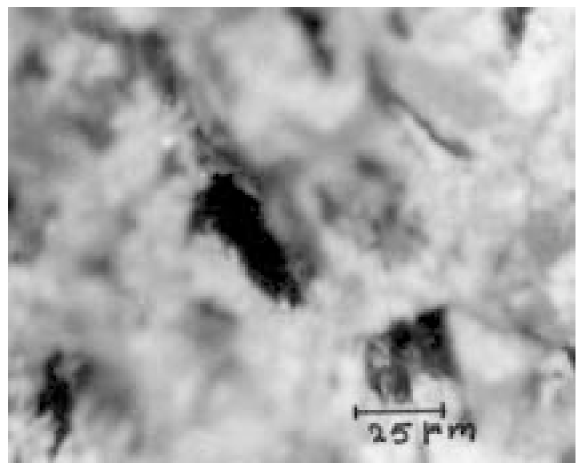

Figure 4. Optical micrograph of the pottery disc containing coarse sand (1000 to 1500 μm diameter)

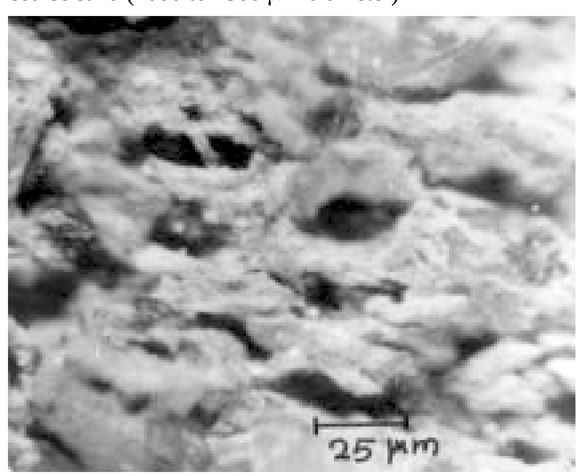

Figure 5. Optical micrograph of the pottery disc containing organic matter (10 % by weight of clay)

For instance, a comparison of Fig. 3 (samples containing fine sand) and Fig. 4 (coarse sand) signify an uneven distribution of larger pores in the latter. These fewer but large-sized pores are presumably responsible for the higher rate of diffusion of water through samples containing coarse sand. Similarly, a comparison of the micrographs of the samples containing fine sand (Fig. 3) and organic matter (Fig. 5) indicate that the samples with a higher proportion of organic matter have had a larger number of evenly distributed pores. This explains the increased rate of diffusion with increasing proportion of organic matter in the pottery mix. Furthermore, the pottery prepared with organic matter gave more consistent rate of diffusion compared to the sand-mixed samples. The even distribution of pores in the micrograph of the organic mixed samples provides a plausible explanation for this. From the present study, it can, therefore, be concluded that the rate of diffusion of water through potteries can be regulated by altering the relative proportion of organic matter or particle size distribution of sand in the clay-mix during the fabrication process. Nonetheless, to standardize the precise proportion of organic matter and/or the particular size distribution of sand in the clay-mix to produce a certain diffusion rate, more detailed experimentation is probably necessary. The present information, nevertheless, can be considered as a modest beginning in this direction, i.e., for designing of pottery products fit for controlled release of water from the pitchers.

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