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Physical properties and hydrological response of green roof substrates based on recycled construction materials

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Green roofs in urban areas improve the building's energy efficiency and provide a wide array of additional environmental benefits. Characterizing and predicting the physical properties and hydrological response of green roofs is necessary to understand the roof's heat balance, which is controlled to a large extent by the substrate's water content, to predict the runoff response and functioning as a part of sustainable urban drainage systems and to plan irrigation of the plants in drier climates. This study examines 10 different extensive green roof substrates, based on recycled construction materials. Green roof simulation decks were installed in boxes of 0,6 m x 0,4 m to a depth of 70 mm, 10 with and 10 without plants. Total water holding capacity of the substrates varied between 10,4 - 23,9 %, with an additional 19 % retained by the drainage layer and geotextiles used in the simulation deck. An important compaction of 30 % on average was observed after 1,5 months. Final bulk densities are between 1457 – 1993 kg m-3. In an evaporation experiment, it was shown that the water evaporated from the green roofs is controlled mainly by the relative moisture content. Substrate properties exerted only a secondary control, with the lowest evaporation rates from the substrates with highest coarse crushed aggregate content and with the highest clay content. The evaporation model proposed here was shown to work well to simulate the evolution of the water balance and therefore the specific unit weight over longer time periods in all substrates, with a Nash-Sutcliffe model efficiency of 0.989. Finally, plants were found to grow satisfactorily in all substrates. Therefore, when regular irrigation is provided, it was concluded that green roofs based on recycled construction materials are a viable option. Future research will have to explore the long-term plant dynamics under water-limited conditions.