A comparative study of the impact of greywater and freshwater irrigation on plant growth and biomass production

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Aim and scientific relevance:

Climate change has put increasing stressors on water resources and energy efficiency. Green buliding infrastructure, such as green walls, is seen as one way to improve energy efficiency of the built environment as well as livability of urban environments. However, water demands for such infrastructure are high. Recycling of lightly polluted greywater (GW) could be a suitable replacement for freshwater (FW), but the comparative response of ornamental plants to greywater is not commonly reported. On one hand, various chemical and physical properties may be detrimental to plant survival such as specific xenobiotic compounds, pH and salinity, while on the other nutrients present in greywater may help to promote plant growth. Therefore this study aims to conduct a comparative analysis of plant growth by applying freshwater and greywater as irrigation alternatives.

Materials and Methods:

To fulfil this study, a small-scale pot test was conducted for 90 days considering one ornamental plant, *Ruellia tuberosa*, with an average height of 20 cm. The temperature condition during the experiment ranged from 36.4 °C to 43 °C and relative humidity in the ranges of 29% to 51%. The pots had a diameter of 14 cm and a height of 12 cm. They were filled with 450 g of plant-growing media consisting of a 2:1 mix of potting soil and sand, and one plant. The pots were clustered into five pairs consisting of one FW irrigated plant and one GW irrigated plant. The pots were placed in the balcony area of a building to give partial sunlight and rotated regularly to ensure equal sunlight availability for all plants. The plants were irrigated daily with 50 mL of GW or FW except for the last two weeks, where 100 mL was used due to the increasing temperature during this period. A synthetic greywater was used to avoid pathogen risks as described by Gildemeister et al.,(2005). Characterization of the greywater was conducted by following the standard methods for water and wastewater (APHA, 2012).

Results and Discussion:

After 90 days of freshwater and greywater supply, each group of pots showed a similar degree of water loss by evapotranspiration ($p>0.05$) as shown in Figure 1a. GW irrigated pots showed greater shoot length in comparison to FW irrigated pots (Figure 1b). The average increase in shoot length was 15% greater for the greywater treatment. In all but one pair, GW application increased the number of fresh leaves compared to the comparative FW supply, but no significant variation was observed in the number of shed leaves ($p=0.143$) between the two watering conditions (Figure 1c and 1d). Additionally, some new sprouts of the branch in each group of planted pots were observed by supplying GW. No new sprouts were observed by irrigating with FW.

The reduced shoot growth, leaf development and possibly flowering in the FW irrigated system are likely due to a lack of nutrients to develop the plant physiology. FW plants may obtain nutrients initially from the soil initially, but in the long run, they may not be able to get from TW, while greywater application fulfills the nutrient requirement. In each group, leaf length and leaf width are slightly increased, but not significantly so ($p = 0.106$), by applying GW (Figure 1d). An insignificant variation was noticed for the number of leaves suffering chlorosis ($p = 0.311$) and branches developed ($p = 0.124$) (Figure 1e), giving further evidence that greywater was not detrimental to plant growth. However, leaf chlorophyll content was significantly greater ($p = 0.214$) in freshwater supply pots (Figure 1f). The data shows that the stem biomass is higher for GW plants by an average of 43% compared to FW plants (Figure 1g). The root biomass observed in greywater-supplied pots was higher than FW plants by an average value of 23%, implying that more nutrients are available in GW plant roots than in FW plant roots. In leaf biomass, pairs 2 and 4 have more biomass in FW than GW by nearly 13%, and all other pairs have higher leaf biomass in GW plants by an average of 40%. It may be due to more chlorosis effect in GW leaves.

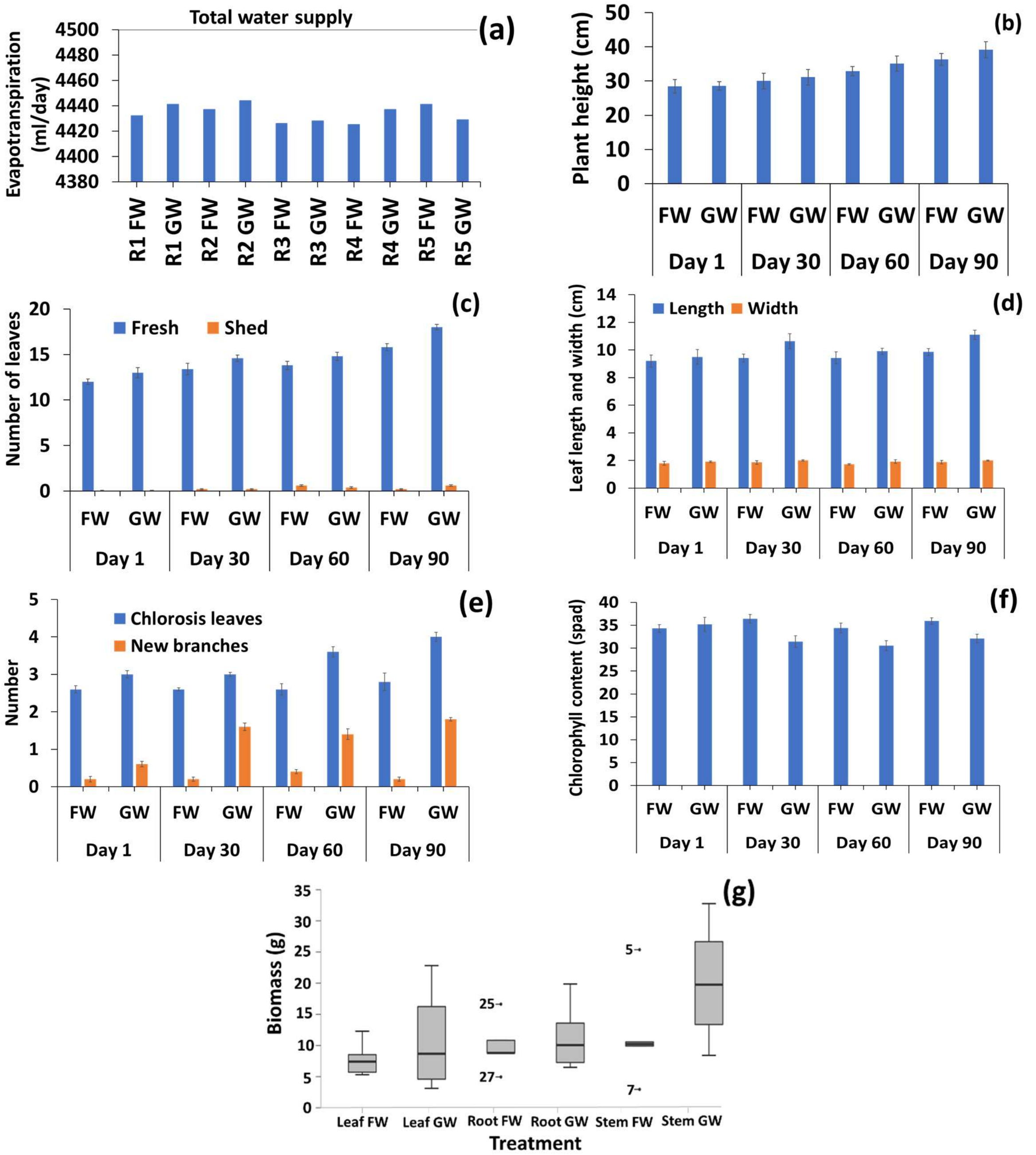

Figure 1:(a)Total water evapotranspiration by plant pairs after 90 days of observation (b) shoot length (c) number of leaves (d) leaf length (e) number of branches and chlorosis (f) leaf chlorophyll content (g) stem, leaf and root biomass after 90 days. *GW: greywater; FW: freshwater*

Conclusion:

Green walls offer multiple benefits to urban buildings, but the major concern is high water demand for plant growth in dry climates. This study shows that GW improved plant growth based on stem height, leaf structure and plant biomass, suggesting GW recycling is a sustainable approach to replace FW supply in green wall design to reduce water scarcity. GW also provides nutrients to the plant which cannot be fulfilled by FW supply.

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