Evaluation of the Performance of the Memorial Stadium Green Infrastructure

Introduction

Green roofs have been used by households for centuries, although perhaps in more primitive forms than today. More recently, corporations looking to invest in green initiatives, either for the sake of image or the environment, have been installing green infrastructure onto their buildings, predominately for aesthetic purposes. Green roof designs began to be constructed on buildings for rainfall recycling, thermal balance, and to bring "green" into city areas. As green infrastructure becomes more popular and prominent in our society, it is necessary to understand what makes a system successful, and how to make it as efficient as possible. To do this, several factors of this complex system were observed at the Memorial Stadium Green Infrastructure located in Manhattan, Kansas (Fig 6 & 7).

Media Selection

By Erin Bush

A native soil system is one that is complex and varies based on climate, time, relief, biota, and parent material. Each of these factors contributes to determining the productivity of a soil by dictating soil texture, nutrient status, and water holding capacity. When constructing a green infrastructure, it is important to note these formation factors in order to determine the limitations with plant type, weight, erosion potential, etc. for success of the roof.

The Memorial Stadium Green Roof is constructed to be a 6" deep substrate predominately composed of sand, with the addition of a peat mixture for structure and nutrients and larger gravel at the bottom for filtration and stability. The sand substrate adds weight, but due to its inability to hold water compared to a media higher in clay, it is less heavy when water is added. This attribute can be a limiting factor for grass species' success as Net Primary Productivity.

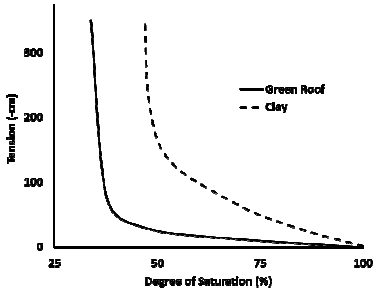


Figure 1. Water release curve of the Memorial Stadium Green Roof compared to a high-clay soil similar to soil types found in the Tallgrass Prairie. The tension at field capacity occurs at much lower saturation levels in a sand (Green Roof) compared to a clay.

https://stormwater.pca.state.mn.us/index.php?title=File:Typical_native_soil_vs._Typical_Green_Roof_Profile.jpg

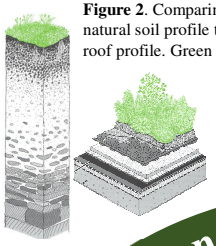


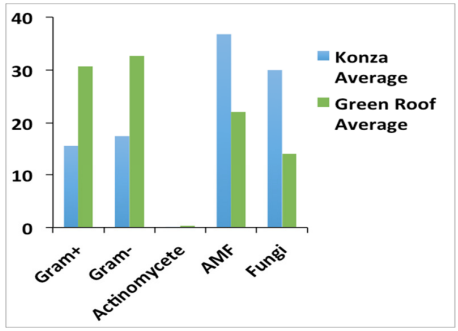
Figure 2. Comparing the profile of a natural soil profile to a common green roof profile. Green roof profile is much more shallow and is composed of some artificial materials.

Microbial Health

By Konner Cool

Soil microorganisms play a vital role in plant health. Microbes are the main decomposers of organic matter, they also fix nitrogen, detoxify harmful chemicals, form stable soil aggregates, and form symbiotic relationships with plants. It is necessary to analyze factors affecting soil microbial populations and understand the benefits of microbial communities in green roofs. This will help to develop practices that use microbes to maximize the water and energy use balance at memorial stadium. Microorganisms are concentrated in top soils 5-10cm deep and near roots, where food and sunlight are abundant.

Using a Phospholipid Fatty Acid Analysis (PLFA) it is possible to determine the microbial abundance and diversity within a sample of top soil. To conduct a PLFA, a sample of soil needs to be collect at a depth of 10cm. The sample then stored at 4C, freeze dried for 48 hours, ground, and then put through a series of chemical extractions. These extractions yield fatty acids from the membrane of the bacteria and fungi. Further analysis allows for identification of bacterial sub groups (gram – and gram+) in addition to AMF, and fungi based on the fatty acids' genetic "fingerprint" that is associated with particular groups of organisms.



http://nature.berkeley.edu/soilmicro/methods/BalserPLFA.pdf

Figure 3. PLFA results from a sample of soil from Konza Prairie compared to PLFA from the Memorial Stadium Green roof. Konza shows a higher amount of AMF and fungi, this is typical of undisturbed soils and represents a well established microbial population.

Water-Energy Balance

By Alexandra Lee

Analyzing the function and performance of the green infrastructure at Memorial Stadium in terms of water-energy balance, the study focused on the irrigation needs of the roofs compared to irrigation applied and the affect of green infrastructure on runoff. To determine the irrigation needs of the green roofs, the evapotranspiration (ET) potential of the vegetation was found using climate data from a nearby building and the Konza. This data was then compared to amount of irrigation currently applied to the roof as seen in Figure 4.

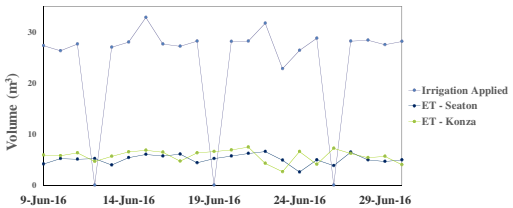


Figure 4. Monitoring results for irrigation applied at the Memorial Stadium green roof compared to calculated ET potential based on two sources of climate data.

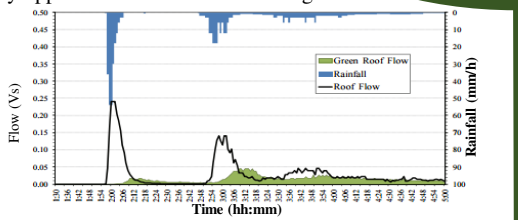


Figure 5. Monitoring results for rainfall event on 8/20/2013 comparing impervious roof and green roof flows (Bonoli et. Al., 2013).

Bonoli, A., Conte, A., Maglionico, M., & Stojkov, I. (2013). Green roofs for sustainable water management in urban areas. *Environmental Engineering and Management Journal, 12*(S11), 153-156.

Another study conducted in Italy investigated the impact of green infrastructure on water retention and runoff. As seen in Figure 5, green infrastructure's retention ability both delays and slows the release of runoff from the roof compared to a typical impervious roof. However, based on the study of Memorial Stadium, the same results may not be found due to over-irrigation. On the 6 days a week the stadium is irrigated, the water applied is three times greater than the ET capacity of the roof. Therefore, rather than delaying runoff, over-irrigation of the roof is actually causing runoff initially and reducing the roof's detention ability by over-saturating the soil. This study concludes that the irrigation of the Memorial Stadium green roof should be reduced to the level of ET potential for the roof.

Health and Well-being

By John Kelly

Although looking at Memorial Stadium Green Roof's internal systems and processes is critical to assessing its performance, it is also important to consider its external impacts, especially the impacts it has on students and faculty at the university. Green infrastructures and other green spaces have been shown to benefit people psychologically and socially.

Figure 6. Gary Felsten (2009) found that students in college perceived scenes of nature, like those found at Memorial Stadium, more mentally restorative than scenes that do not have natural elements.

One of many psychological benefits of green space is stress reduction. Christopher J. Gidlow (2016) conducted a study that measured peoples hair cortisol concentration, a biomarker of chronic stress, and found that being in areas with more higher density of nature settings was associated with lower stress.

Figure 7. Memorial Stadium Green Infrastructure located in Manhattan, Kansas.

Frances Kuo (1998) found that green infrastructure can encourage social ties when he studied residents in an urban environment with access to green spaces compared to residents who did not have access to green spaces. He concluded those with access to green spaces "had more social activities and more visitors, knew more of their neighbors, and reported their neighbors were more concerned with helping and supporting one another."

The two studies help show how green spaces like Memorial Stadium can have an impact on the students and faculty of the university. But they represent a very small sample of the body of literature on the subject. Other studies show that green spaces help people recover mentally, can lead to increased physical health, and are associated with lower crime rates.

Conclusion

The key factors observed that influence the performance of the green infrastructure at Memorial Stadium are substrate, microbial health, water-energy balance, and the health and well-being provided by the structure. In assessing each of these factors, it became apparent that there are many opportunities to improve the system to make a more sustainable green roof. For instance, the use of a sandy mixture reduces the nutrient holding capacity and restricts the ability to hold onto moisture, which is key for native grass species. This substrate also negatively impacts the ability for a diverse microbial community, which would otherwise be found rich in a native prairie. Also, irrigation was found to be excessive after analyzing the ET capacity of the green roof. However, the aesthetic and community aspects of this green infrastructure provide social benefits.

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. Journal of Environmental Psychology, 29(1), 160-167. doi:10.1016/j.jenvp.2008.11.006

Gidlow, C. J., Randall, J., Gillman, J., Smith, G. R., & Jones, M. V. (2016). Natural environments and chronic stress measured by hair cortisol. Landscape and Urban Planning, 148, 61-67. doi:10.1016/j.landurbplan.2015.12.009

Kuo, F., Sullivan, W., Coley, R., & Brunson, L. (1998). Fertile ground for community: Inner- city neighborhood common spaces. American Journal of Community Psychology, 26(6), 823-851. doi:10.1023/A:1022294028903