Report for 2003CO71B: Urban Landscape Irrigation with Reclaimed Wastewater, Phase 2: Current Knowledge and Community Experience

- Other Publications:
    - Qian, Y.L., 2003, "Salt tolerance should be considered when choosing Kentucky bluegrass varieties," Turfgrass Trends, 12(6):62-64.
    - Qian, Y.L., 2003, "Can turfgrass sequester atmospheric carbon? Assessment using longterm soil testing data," Turf News: March/April 2003, p. 23-6.
- Articles in Refereed Scientific Journals:
    - Alshammary, S., Y.L. Qian, and S.J. Wallner, 2004, "Water relationship of cold and warm season turfgrasses under saline water irrigation," Aust. J. of Agricultural Research, in press.
    - Alshammary, S., Y.L. Qian, and S.J. Wallner, 2004, "Growth response of four turfgrasses to salinity," Agricultural Water Management 66:97-111.
- unclassified:
    - Qian, Y.L., R.F. Follet, S. Wilhelm, A.J. Koski, and M.A. Shahba, 2004, "Carbon isotope discrimination of three Kentycky bluegrass cultivars with contrasting salinity tolerance," Agron. J. 96:571-575.

Report Follows

Problem and research objectives:

Growing concerns of our future water supply and more stringent wastewater discharge standards to surface water bodies have contributed to increasing interest in using recycled wastewater for urban landscape irrigation. Like many other places in the world, cities along the Front Range of Colorado plan to expand wastewater reuse systems. Therefore, increasing numbers of landscape facilities and development areas have planned or have switched to recycled wastewater (RWW) for irrigation. To provide relevant information, the objectives of this project are:

1) To conduct a literature review and synthesize current knowledge to provide information on: a) guidance in monitoring water quality and soil and plant health; and b) best management practices for urban landscapes under recycled wastewater irrigation.
2) To evaluate landscape plants and soils along the Front Range of Colorado that are currently under recycled wastewater irrigation in comparison with plants and soils with conventional water source irrigation.

Methodology and progress:

To access current knowledge concerning the effects of irrigating with RWW on landscape plant performance and soil characteristics, we have collected and reviewed literature to assess trends of changes in key soil properties such as, salinity, sodicity, infiltration rate, hydraulic conductivity, heavy metals elements, etc. We found that soil salinity increments under wastewater irrigation are a function of water quality, soil texture, drainage effectiveness, topography, climatic, and management practices. Sodium adsorption ratio, total suspended solid, C:N ratio, and bicarbonate content of RWW directly affect water infiltration and percolation. To predict the resistance of targeted landscape plants to long-term RWW irrigation, literatures on the relative salinity tolerance of landscape plants were reviewed. A list of landscape plants [different turfgrasses, bedding plants, evergreen woody plants, and deciduous woody plants] and their general rankings of the salinity tolerance of individual plants were summarized. Currently, we are conducting further research to generate best management practices for urban landscapes under RWW irrigation

To evaluate landscape plants and soils along the Front Range of Colorado that are currently under recycled wastewater irrigation in comparison with plants and soils with conventional water source irrigation, we selected 12 urban landscape sites with 6 sites that have been irrigated with RWW exclusively for 5-34 years and the 6 other sites that have been irrigated with surface or municipal water as controls. From each site, soil, irrigation water, and plant samples were collected and analyzed for salinity, sodicity, and other ion content. In addition, on two landscape sites, soil samples were collected prior to and 4 or 5 years after the commencement of recycled wastewater for irrigation. Those soil samples were analyzed for salinity, sodicity, pH, and other ion content.

Principal findings and significance:

1. Recycled wastewater samples collected from the 6 reuse sites exhibited average EC value of 0.84 dS/m. The chemical constituent of recycled wastewater is dominated by sulfate, bicarbonate, chloride, and sodium. Adjusted sodium absorption ratio (SAR) of recycled wastewater from reuse sites ranged from 1.6 to 8.3. Based on the interactive effect of salinity and sodicity on soil infiltration and percolation, 90% of the water samples collected showed slight to moderate effects on soil infiltration and permeability. The average sodium and chloride concentrations of 37 water samples collected were 99 mg/L and 95 mg/L, respectively. Most of the surface water used on the control sites came from melting snow of the Rocky Mountains and exhibits good quality with average EC, SAR, sodium and Chloride content of 0.23 dS/m, 0.9, 15 mg/L, and 8 mg/L, respectively.

2. Our results indicate a substantial impact of recycled wastewater on soil properties. Soil samples in the 0-11.4 cm depth from reuse sites exhibited 0.3 units of higher pH and 200%, 40%, and 30% higher concentrations of extractable Na, B, and P then the control sites, respectively. Compared to sites irrigated with surface water, sites irrigated with RWW exhibited 187% higher EC and 481% higher sodium adsorption ratio (SAR) of saturated paste extract. However, extractable Mg was reduced 15% ($P < 0.005$). Comparison of soil chemical properties before and 4 or 5 years after RWW irrigation on two golf courses also revealed the following findings:
   a) 89-95% increase in Na content;
   b) 28-50% increase in B content; and
   c) 89 - 117% increase in P content at the surface depth.

   Regular monitoring of site-specific water and soil and appropriate management are needed to mitigate the negative impacts of sodium and salts accumulations.

3. Although greater variations in the incidence of needle burn or dieback existed, ponderosa pines grown on sites irrigated with RWW exhibited 10 times higher needle burn symptoms than those on sites irrigated with surface water (33% vs. 3%). The needle burn symptoms included the development of needle tip necrosis, resin-infiltrated bands, and necrosis of distal regions of needles. As the symptoms developed further, leaf falling or thins could occur. Tissue chemical analysis indicated a much higher sodium concentration in the affected trees. Ponderosa pine needles collected from reuse sites exhibited 11 times higher Na content, 2 times higher Cl, and 50% higher B content than samples collected from the control sites. Stepwise regression analysis revealed that the level of needle burn was largely influenced by leaf tissue Na content. Additionally, increasing Cl, B, Ni and Cu also exhibited positive relations with increasing levels of needle burn. Tissue Ca level and K/Na ratio were negatively associated with needle burn, suggesting calcium amendment and K addition may help mitigate the needle burn syndrome in ponderosa caused by high Na in the tissue.

4. Turfgrass grown under RWW exhibited acceptable quality and turf quality was not significantly different from turf receiving surface water for irrigation. However,

clippings collected from sites with RWW for irrigation exhibited 6.4 times higher Na content and 1.3 times higher B content than sites irrigated with surface water, reaching 3315 and 448 mg kg^{-1}, respectively.

From our initial study we found that both problems and opportunities exist in using RWW for landscape irrigation. Recycled wastewater irrigation in urban landscapes is a powerful means of water conservation and nutrient recycling, thereby reducing the demands of freshwater and mitigating pollution of surface and ground water. However, potential problems associated with recycled wastewater irrigation do exist. These problems include salinity build up and relatively high Na accumulation in the soil and plants. Salt leaching would become less effective when soil hydraulic conductivity and infiltration rate were reduced. These chemical changes may in part contribute to the stress symptoms and die off observed in some ornamental trees and, to a lesser degree, in Kentucky bluegrass/perennial ryegrass turf. As more landscape facilities and development areas switch to recycled wastewater for irrigation, landscape managers must be prepared to face new challenges associated with the use of recycled wastewater. Persistent management practices, such as applications of soil amendments that provide Ca to replace Na; periodic leaching to reduce salt accumulation; frequent aerifications to maintain infiltration, percolation, and drainage; regular soil and plant monitoring, and selection and use salt-tolerant turfgrass and landscape plants will be helpful in mitigating the negative impact and insuring continued success in using RWW for landscape irrigation.