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Week Three Lit Review
Winter 2016 SOS - Edible Landscaping with E4E

Last week I was left asking myself “what would I do if a client wanted to grow tomatoes in a lawn that had lead (Pb) toxicity?” “How often will I come across someone with too much arsenic (As) where they want to put apple trees?” The obvious and ethical answer is “don’t grow food there, buy it from someone else, get a neighborhood garden plot.” However this problem could be more common among my clientele than I expect because Thurston county has been developing on what use to be agricultural land (which as I’ll explain later has a high degree of homogenous toxin enrichment within the soil) and we’re part of the southern reach of the Asarco smelting plume which deposited both arsenic and lead into the surrounding county soils. Farmers here traditionally try to keep the pH of the soil basic so they don’t liquify the lead and arsenic in the soil and thus make them more bioavailable. By keeping Arsenic and Lead in solid forms and keeping them lower than the annual root zones, farmers and gardeners are safe from these toxins. However, what about perennial plants with deep roots who like an acidic soil? Since I’m working on edible landscaping with a focus on perennials, should I start organizing my plant list to those which do not bioaccumulate these toxins?

Szolnoki, Farsang, and Puskas (2013) wrote the article Cumulative Impacts of Human Activities on Urban Garden Soils: Origin and Accumulation of Metals, in which they inventoried 50 soils in Hungary for metal enrichment therein. As they say, even if the food being grown do not bioaccumulate toxins, any lingering soil on the food could enter the eater’s system- the same goes for children who tend to eat soil for fun. What they ultimately found is that compared to the parent material and soils found in surrounding rural lands, there is a higher concentration of metals in the garden soils. They found that, for some metals, it didn’t matter what kind of garden they were surveying (orchards, veggies, flower gardens) as those metals were ubiquitous. Copper (Cu) specifically was found in high amounts in orchards and veggie patches, due mainly to the “cide” of choice applied to both sites. Table 4 from the paper shows their inventory findings and highlights my concerns, especially regarding Pb and As which, as I mentioned earlier, is probably higher in Thurston thanks to Asarco. Additionally these values differ depending on their distance from trafficked roads.

Table 4
The average metal concentration (mg/kg) measured in the topsoil (0–10 cm) in different garden types.

Type of garden		As	Zn	Cd	Pb	Ni	Co	Cr	Cu
Vegetable garden $N = 31$	Mean (mg/kg)	6.86	75.70	0.47	14.46	21.97	6.23	29.85	66.62
	S.D.	2.47	22.50	0.11	5.32	4.90	2.54	7.17	98.68
Orchard $N = 9$	Mean (mg/kg)	8.30	87.63	0.78	19.24	23.31	5.83	34.04	64.54
	S.D.	2.34	38.80	0.80	16.12	4.68	1.60	9.60	31.99
Flower garden $N = 11$	Mean (mg/kg)	7.21	86.65	0.59	16.31	23.89	5.92	33.22	33.04
	S.D.	1.70	43.36	0.24	5.44	4.20	0.82	3.70	9.98

On page 111 section 4 paragraph 1 the article says that 18% of the lawns inventoried had high metal enrichments in comparison to the “native” metal levels. If I take this statistic at face value and apply it to Olympia I could foresee 1.8-2 out of 10 clients with unsafe lawns. Or rather, 1 out 5. That’s a rather high number. This number could increase depending on how close to the road the lawns are, specifically in regards to zinc (Zn), cadmium (Cd), and Pb.

I followed the above article with Fiona Wong et. al (2012) article Fate of Brominated Flame Retardants and Organochlorine Pesticides in Urban Soil: Volatility and Degradation. Brominated Flame Retardants (BFRs) are applied to household furnishings and other items to prevent them from catching fire. Organochlorine pesticides kill insects and are highly insoluble in water due to their strong molecular bonds. The most famous Organochlorine pesticide is DDT. Both classes of chemicals are banned precisely for the fact that they are found so ubiquitously in the environment. While they have largely been phased out in most countries, soils, as the storage pools for these chemicals, will soon become emitters of them as they degrade and volatilize. Further polybrominated diphenyl ethers (BDEs) which make up BFRs are found within sewage sludge, and it’s not unheard of for farmers to apply sewage sludge on their fields purposefully as an off season compost, or accidentally as in the case of floods.

Now as the article says, only a fraction of the chemicals will volatilize into the atmosphere, and the rest will be trapped within in the micropores. Being that urban sprawl incorporates what use to be agricultural land, gardeners may find their soils polluted with the above chemicals. What the scientists found was that, over 700 days, the chemical volatility decreases due possibly to the micropores. On page 2671 they reference Liu et al. in explaining that sorption in the soils of these chemicals happens in two phases; in the first phase these chemicals are absorbed very fast, and then in the second phase, they are absorbed very slowly. In time, thanks to the work of microbes, the chemicals bound to the soil residues and require extended means to be extracted. They found that air is a mild extractant, meaning the chemicals will stay in the soil.

My next article, Phytoavailability and Fractions of Iron and Manganese in Calcareous Soil Amended with Composted Urban Wastes by Francisco Gallardo-Lara et al. (2006) surveyed the growing patterns of crops after applications of a compost of municipal solid waste (msw) and/or municipal solid waste-sewage sludge mix. As I explained earlier some conventional farmers do use these composts as soil amendments because they can increase amounts of humus within the soil. However there’s a discrepancy of Iron (Fe) and Manganese (Mn) levels in these scenarios which this article explored.

They treated greenhouse potted plants of lettuce and barley with varying mixes of these amendments and measured the concentrations of Mn and Fe in various locations on the plants. They found that within calcareous soils MSWs had a delayed improvement on crop growth, but it was a better improvement than those found with the MSW-SS mix. However the Fe levels within lettuce were still in the deficiency range no matter the compost mix used, and only slightly increased the Fe levels in parts of the barely. The Mn levels within lettuce were in the sufficiency range, but not so with barely probably because of the delayed nature of the compost mixes and their reactions to chelating agents also found within the compost mixes.

The take-home message? If you're using only municipal solid waste as part of your urban yard compost mix (because sewage sludge probably is legal for urban home use) then find amendments or plants which can bring Fe into the system for the annual plants, and Mg for the perennial plants.

My next article comes from Groffman, P. M., et al. (2006) and is titled Land Use Context and Natural Soil Controls on Plant Community Composition and Soil Nitrogen and Carbon Dynamics in Urban and Rural Forests. This article explores how land use effects C and N cycling in comparison to what the local land already does, and how the N cycle and its fluxes affect anthropogenic activities. As they say, with ~110,000 km^2 under impervious surfaces, it's easy to see how the N and C cycles could be disrupted sense most of either cycles take place underground. In contrast, urban forests can have positive effects on these cycles. However, what they found was strikingly unintuitive.

The paper explains that any discrepancy in N cycling in the urban forests are due mostly to soil type- not proximity to urban environments, but is largely powered by the presence and actions of earthworms. The C cycle and its fluxes are "strongly influenced by exposure to altered disturbance regimes and atmospheric chemistry associated with urbanization" (page 186). Depending on what the city off-gases, the urban forests will breed out those individuals which can't handle the upsurge in pollution and the composition will change. This change is slower among the long lived canopy trees but quicker in the sapling, shrub, and ground layers, and it is in these layers that we can see our urban impacts reflected back at us.

They also found that urban soils are more fertile than rural ones because of the lack of the plow and its effects. Section 4.2 was very interesting to me- it explored the spp composition of urban plots to rural to forest. These compositions mimic a habitat and how the plants would like to situate themselves. For example, in this study, they found that urban plots had more tree canopy gaps which opened up light for the lower layers, and the vining plant spp beta richness was increased to 6 different spp. This is the system which the plots in this study will passively support- which means it is the least expensive system for the homeowner to manage. Which means this is the system I should promote: lightly leafed canopy trees supporting fruit producing vining plants with fruit producing shrubs, perennial vegetables, and a section for annual vegetables. This bit of information is the most applicable to my research, so I'll move on from this paper and go to the next.

The paper Density and Stability of Soil Organic Carbon Beneath Impervious Surfaces in Urban Areas by Zongqiang Wei et al. (2014) explores further the largely unknown impact on the carbon cycle posed by impervious surfaces. Since impervious surfaces aren't really my focus, I'll just briefly explain their findings: impervious surfaces in urban areas have a negative impact on the urban ecosystem because of the lack of greenspaces and thus lack of opportunity to sequester C. This lead me to my next question, a theoretical question, not something I'll explore too far- If ~110,000 km^2 is covered in impervious surfaces, which affects the C cycle by prevented C sequestration, than is it appropriate to add conventional, annual agricultural land to the "impervious surface" count, based solely on the fact that such lands do not sequester C? In fact, these lands off-gas C. If the answer to my question is yes, than there are a lot of impervious surfaces out there.

Finally, my favorite paper this week, by Nezat et al. (2016). Heavy Metal Content in Urban Residential and Park Soils: A Case Study in Spokane, Washington, USA in another inventory-eque article. The scientists sampled soil cores from thirty different locations: 14 parks, 20 residential yards, and 6 gardens, for the presence of heavy metals and compared the samples to the natural soils present to find any excessive levels which could be caused by anthropogenic activities. While Spokane is different from Olympia in weather, they did do similar economic activities, like mining, agriculture, and timber, so their data is somewhat directly similar to what Olympia might see in its soils.

Noteworthy and applicable findings to me were: the elevated levels of As in rural plots were distributed homogeneously throughout the soil profile due to the soil structure degrading nature of the plow; elevated levels Pb from historical use of Pb based gasoline within the upper soil levels of urban and garden plots; elevated levels of Pb, Ba, and Zn in urban and residential soils due to out-dated lead-based paint; and 2 sites with levels of As and Pb which exceeded safety standards- that means if I take these statistics at face value, then 2/30 or 1/15 of my clients will have As and Pb levels that are too high for me to ethically garden their land for edible plant use.

The above papers were most of my Upper Division readings. I supplemented these readings with Dr. Dickson Despommier's book <u>The Vertical Farm: Feeding the World in the 21st Century</u> written in 2010. This was pretty light reading with redundant chapters. He was basically making the case for farming within very tall buildings. He had eleven reasons for doing so, which can be found on page 145 and should sum up his book satisfactorily enough. The advantages of a vertical farm: 1) year round crop production; 2) no weather related crop failures; 3) no ag runoff; 4)ecosystem restoration; 5) no cides or ferts; 6) use 70-95% less water; 7) reduced food miles; 8) more control over food safety and security; 9) new employment opportunities; 10) purification of grey water to drinking water via evapotranspiration, and 11) animal feed from post harvest materials.

Now, I have some concerns about farming in absence of the true soil, mostly the importation of so many materials and nutrients, but if we shifting the way we compost our waste products, and even our own dead bodies, we might be able to balance these issues. Additionally, if the tower windows were lined with photovoltaic panels, we could generate a lot of electricity therein. I finished this book this week and am halfway through The Bio-Integrated Farm by Shawn Jadrnicek. It's a fascinated book and I'll talk about it more next week.

So now I'm left asking the question: which plants are safe to eat on a metal enriched yard? What options do I have to make a yard safe? Is that beyond the scope of my business? Or can I include yard remediation as a product?

Until next time.

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