

A Pot Trial Comparison of Vetiver and Three Other Warm-Season Grasses Irrigated with Highly Saline, Alkaline Landfill Leachate

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Vetiver Grass (*Chrysopogon zizanioides*)

- ▶ Sterile, perennial clump grass grown in tropical, subtropical, and Mediterranean climates.
- ▶ Used in bioengineering applications such as slope stabilization, erosion control, land reclamation, and contaminated water treatment = Vetiver System (VS)
- ▶ Tolerant to a wide variety of climate and environmental conditions, including drought, fire, frost, flooding, contaminated land and polluted water, and poor soil quality.
- ▶ Highly tolerant to acidity, alkalinity, salinity, sodicity, excess nutrients, heavy metals, pesticides, and organic compounds.
- ▶ Highly efficient at absorbing large volumes of water, nutrients, and heavy metals.

= Great tool for the prevention/remediation of contaminated land as well as the treatment and disposal of contaminated water.

Using Vetiver System at Landfills

- ▶ The Vetiver System (VS) has been used at landfills in numerous ways throughout the world, including as a leachate disposal method, to help reduce rain infiltration into the waste, as part of a treatment or polishing constructed wetland process, and to help soak up seeps.
- ▶ In the USA, Leachate Management Specialists (LMS) uses the VS as part of some of their Phyto-Utilization™ systems, which uses fast growing and non-invasive plants like vetiver to consume leachate on-site to greatly reduce or eliminate the need for other disposal methods. The liquid is used as moisture and the contaminants act as macro and micro nutrients to help fuel fast growth.
- ▶ LMS works closely with Dr. Paul Truong, world vetiver expert, during the design and modeling process of any new vetiver project to ensure the leachate quality will not be toxic to the plants.
- ▶ This pot trial was set up to compare tolerance of vetiver to other warm-season grasses using leachate that is highly saline, alkaline, and containing high levels of other contaminants.



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The Trial

To evaluate vetiver's tolerance to strong landfill leachate as compared to other warm-season grasses, a pot trial was completed in the early Fall 2021 near Philadelphia, Pennsylvania, USA. The plants tested were:

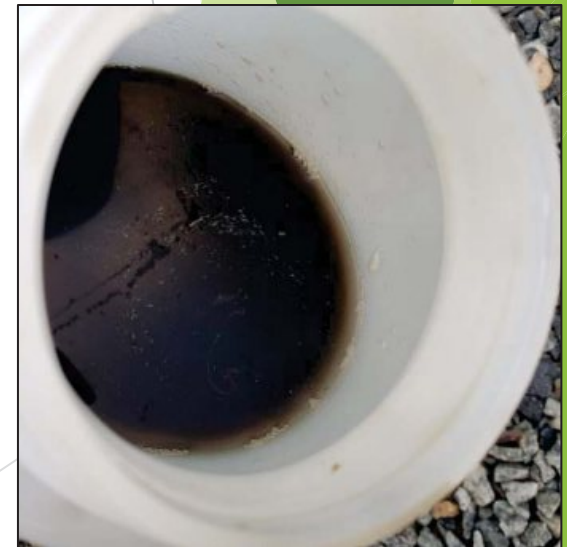
- ▶ Vetiver - 'Sunshine' cultivar
- ▶ Vetiver - 'Malawi-Lilongwe' cultivar (similar in DNA to Sunshine)
- ▶ Big Bluestem (*Andropogon gerardii*)
- ▶ Indiangrass (*Sorghastrum nutans*)
- ▶ Switchgrass (*Panicum virgatum*).

Two pots were set up for each plant, one for leachate irrigation and one as a control. Each week, leachate was applied to the Irrigated set in incremental doses. The trial lasted five weeks, with each Irrigated plant receiving a total of 1.6 liters (6.8 cups) of the leachate.

Leachate Quality

- This leachate is very dark in color and has a strong pungent odor.
- Elevated levels of EC, TDS, Na, Cl, B, pH, SAR, bicarbonate, etc.

Analyte		Units	Leachate
Alkalinity, Total	CaCO3	mg/L	5,800
Ammonia Nitrogen	NH3-N	mg/L	700
Total Kjeldahl Nitrogen	TKN	mg/L	850
Nitrate Nitrogen	NO3-N	mg/L	< 10
Nitrite Nitrogen	NO2-N	mg/L	50
Nitrogen, Total	N	mg/L	900
Bicarbonate	HCO3	mg/L	6,000
Carbonate	CO3	mg/L	500
Chloride	Cl ⁻	mg/L	4,100
Conductivity	EC	µmho/cm	25,000
Hardness, Total	CaCO3	mg/L	1,100
pH	pH	s.u.	8.5
Phosphorus, Total	P	mg/L	13
Sulfur, Total	S	mg/L	75
Total Dissolved Solids	TDS	mg/L	14,800
Boron	B	mg/L	14
Calcium	Ca	mg/L	215
Iron	Fe	mg/L	26
Magnesium	Mg	mg/L	135
Manganese	Mn	mg/L	0.7
Potassium	K	mg/L	805
Sodium	Na	mg/L	3,300
Sodium Adsorption Ratio	SAR	ratio	44



Set-Up

- ▶ Several holes were poked into the bottom of the pots to prevent oversaturation.
- ▶ Each pot was filled with a mix of topsoil and potting soil.
- ▶ The plants were potted in late July 2021 and watered with freshwater as needed, then trimmed to ~ 45 cm (18 in) one month later at the end of August 2021 for the start of the trial.



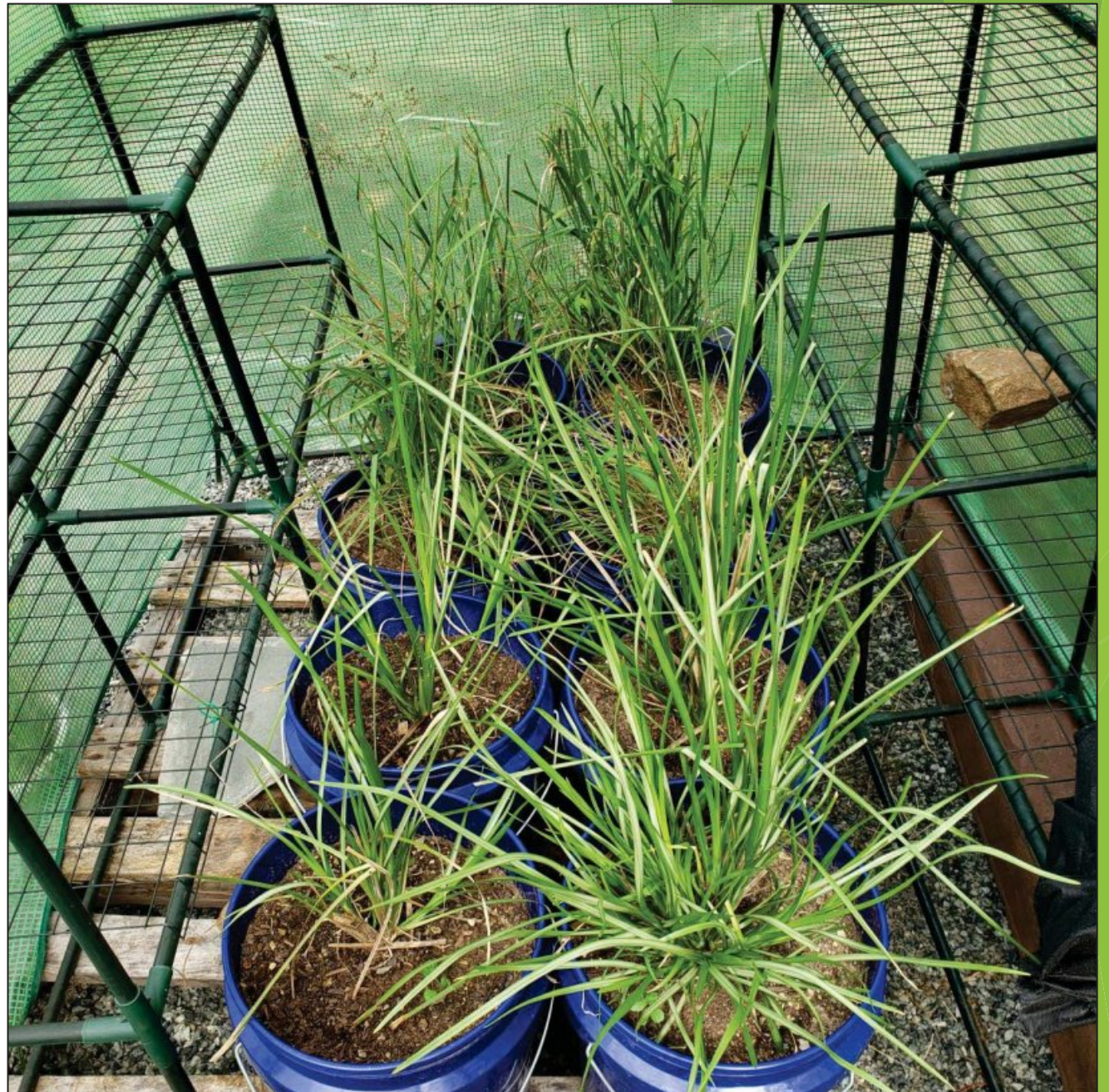
Start of Trial

- ▶ ~ 0.2 liters (0.85 cups) of leachate were poured into each of the Irrigated pots (left side).
- ▶ The pots were moved into a small greenhouse to prevent oversaturation from rainwater.
- ▶ Freshwater was added to every pot throughout the trial as needed.
- ▶ The plants all appeared healthy.
- ▶ Note, the Control plants for both vetiver cultivars (right) started with more shoots. Also, the Big Bluestem Control was slightly bigger than the Irrigated plant, while the Indiangrass Control started out smaller.



Week 1

- ▶ After the 1st week, all the plants were green and growing, and no signs of stress were observed.
- ▶ ~ 0.3 liters (1.27 cups) of leachate were poured into each of the Irrigated pots (left).



Week 2

- ▶ After the 2nd week, some dry spotting (necrosis) and stress were noted on the Irrigated Big Bluestem, Switchgrass, and Indiangrass, but not on the vetiver.
- ▶ ~ 0.4 liters (1.7 cups) of leachate were poured into each of the Irrigated pots.



Big Bluestem: Irrigated has some white/brown spots on leaves and not as lush as Control.



Switchgrass: Irrigated has small black spots on leaves and inflorescence has browned out (left), while Control's is green.



Indiangrass: Irrigated has brown/red spots



Vetiver: Both Controls (top pots) still have more shoots than the Irrigated like the beginning of the trial, but all seem to be growing with no signs of stress.

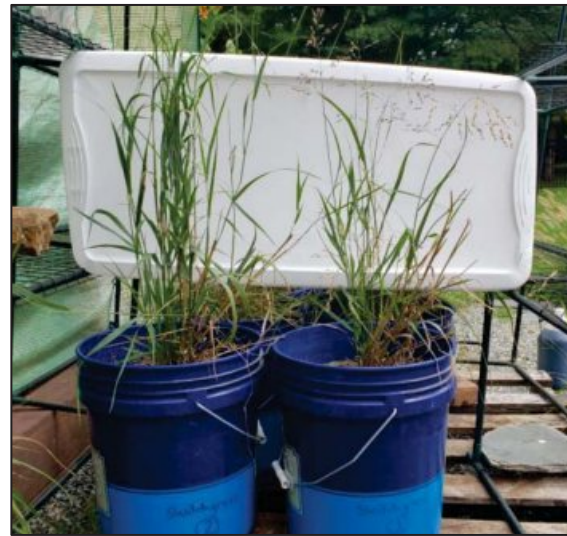


Week 3

- ▶ After the 3rd week, Irrigated Big Bluestem, Switchgrass, and Indiangrass showed signs of stress. Irrigated vetiver is looking good, except that Malawi-Lilongwe has a few yellow leaves now.
- ▶ ~ 0.5 liters (2.1 cups) of leachate were poured into each of the Irrigated pots.



Big Bluestem: Irrigated (right) has some browning and not growing as well as Control.



Switchgrass: Irrigated (right) has browned inflorescence and not growing as well as Control.



Indiangrass: Irrigated has spotting and brown tips, but growing okay.



Vetiver Sunshine: Both growing well, but Control (left) is still larger. No signs of stress on Irrigated (Right Photo)



Vetiver Malawi-Lilongwe: Irrigated (left) has a few yellow leaves now. Control (right) is growing fast.



Week 4

- ▶ After the 4th week, Irrigated Big Bluestem, Switchgrass, and Indiangrass continued to show signs of stress. Irrigated vetiver is looking good, except that Malawi-Lilongwe still has a few yellow leaves.
- ▶ ~ 0.2 liters (0.85 cups) of leachate were poured into each of the Irrigated pots.



Big Bluestem: Irrigated (right) has some browning and not growing as well as Control.



Switchgrass: Irrigated (right) has browned inflorescence and not growing as well as Control.



Indiangrass: Irrigated has spotting and brown tips, also now has inflorescence.



Vetiver Sunshine: Both growing well, but Control is still larger. No signs of stress on Irrigated.



Vetiver Malawi-Lilongwe: Irrigated still has a few yellow leaves. Control is the biggest out of the four vetiver.

Week 5

After the 5th and final week, all the Irrigated plants (I) were smaller than their Controls (C), although the Irrigated vetiver cultivars started out smaller. The Irrigated Big Bluestem, Switchgrass, and Indiangrass showed signs of stress such as dry spotting (necrosis) and brown leaves. Irrigated vetiver showed no stress besides several yellow leaves on the Malawi-Lilongwe plant and a couple of brown tips on the Sunshine plant. Note, the Indiangrass was removed from this photo because the Control was significantly smaller throughout the trial. The next few slides show close-up photos of each.



Week 5 - Big Bluestem



The Irrigated Big Bluestem tolerated the leachate, but it didn't grow as well as the Control and developed some spots and browning, while the Control stayed green.

Irrigated



Control



Week 5 - Switchgrass



The Irrigated Switchgrass appeared stressed from the leachate, with stunted growth, purple spots on the leaves, and browned inflorescence. The Control looked healthier with green leaves and taller growth.

Irrigated



Control



Week 5 - Indiangrass



The Irrigated Indiangrass tolerated the leachate, but it developed some spotting and brown leaves. The Control was a much smaller plant from the beginning of the trial, but no spotting was observed, although it did have some brown leaves and tips throughout the trial.

Irrigated



Control



Week 5 - Sunshine Cultivar of Vetiver



The Irrigated Sunshine Vetiver tolerated the leachate very well with no signs of stress besides a couple of brown tips and possibly stunted growth. The Control had more shoots at the beginning of the trial and ended up growing the tallest leaves out of all the plants.

Irrigated



Control



Week 5 - Malawi-Lilongwe Cultivar of Vetiver



The Irrigated Malawi-Lilongwe Vetiver tolerated the leachate very well with no signs of stress besides a couple of yellow leaves and possibly stunted growth. The Control had more shoots at the beginning and showed healthy fast growth in the trial. This cultivar appears to grow more shoots than Sunshine, but not as tall.

Irrigated



Control



Summary

- ▶ After a five-week pot trial comparing the tolerance of vetiver with other warm-season grasses irrigated with strong leachate, it appears that the vetiver showed fewer signs of stress.
- ▶ The Irrigated Big Bluestem, Switchgrass, and Indiangrass exhibited stunted growth, dry spotting, and brown leaves.
- ▶ Both vetiver cultivars tolerated the leachate well with only a few leaves showing brown/yellow stress. By the end of the trial, the Irrigated vetiver plants were not as big as their Controls, but the Controls had more shoots at the start, so it is difficult to compare.
- ▶ All the plants in this trial were young and not fully established on purpose to evaluate how this strong leachate would impact new plants that were recently put in the ground. A follow-up study could use fully established plants to determine if tolerance limits changed among these species.