Project Update: September 2018

Objectives completed:

A system capable of analysing the phytoremediation capabilities of various plant species was designed and constructed in the Water Laboratory at Stellenbosch University.

The experimental laboratory phytoremediation analysed the bioremediation capabilities of 14 indigenous Renosterveld plant species and four alien invasive plant species currently implemented in constructed wetlands, sustainable urban drainage systems and treatment trains internationally.

Plant species vary with regard to their pollutant removal abilities, with the most effective plant species characterised by long roots, deep root depth, and heavy root mass. The introduction of certain plant species for phytoextraction may however pose a set of alien invasive problems, hence it is necessary to alternatively investigate the removal efficiencies of plant species indigenous to contaminated areas.

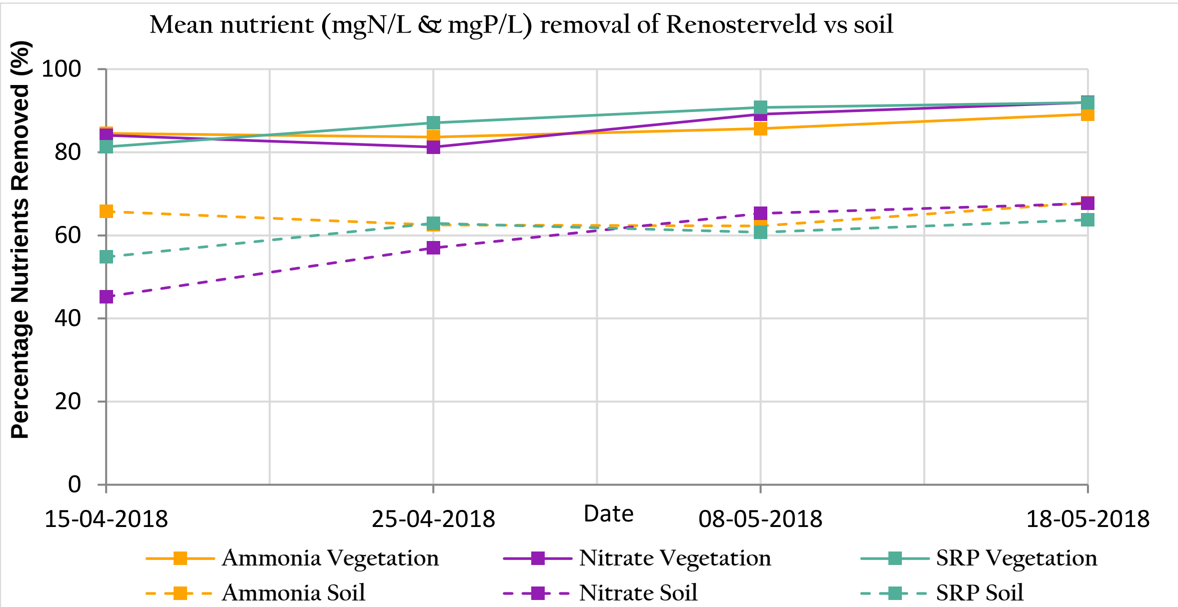
All plant species were carefully transported to the laboratory location, in the Waterlab of the Civil Engineering Department at Stellenbosch University and planted in September 2017 receiving tap water irrigation for 6 months - allowing time to mature and adjust to growing conditions. During the transplantation process, special care was taken to remove all visible foreign organic matter and soil. This limited any external factors contributing to the phytoremediation process, ensuring equal conditions throughout the system.

The soil collected from the relevant field site was inserted and circulated in a 50 l pan mixer at the Civil Engineering department at Stellenbosch University. The pan mixer ensured completely mixed soil conditions before transfer into the growth silos prior to transplantation. The plant roots were handled with extreme caution as not to damage them in any way. If trimming of the stem was necessary, it was done in a manner that wouldn't alter plant development.

Different phytotechnologies utilise different plant properties and typically implement different plant species for each scenario. Properties that have been accepted as advantageous to phytoremediation are: fast growing, high biomass, competitive and high tolerance to pollution.

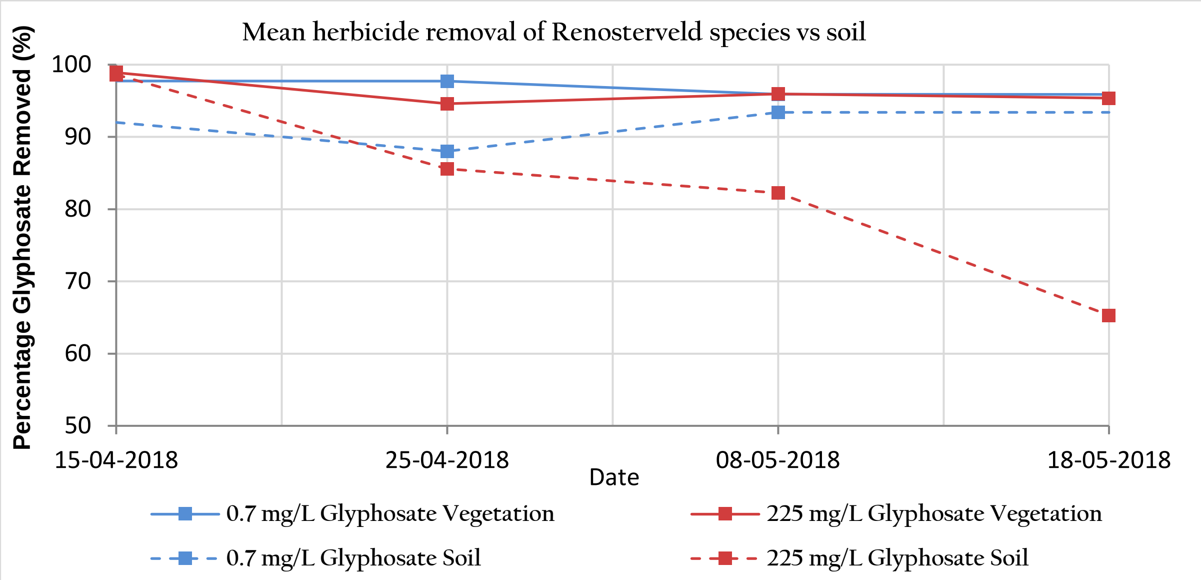
Post municipal irrigation, the plants received standardised contaminated water treatments. These concentrations were selected to represent fertiliser and herbicide pollution of watercourses in the Overberg area, specifically focused on the production of Canola.

The Renosterveld plant species successfully reduced the fertiliser nutrients. The percentage removal averaged 86%, 87% and 88% for ammonia, nitrate and soluble reactive phosphorus respectively. The nutrient removal of Renosterveld vegetation, was consistently greater than that of un-vegetated soil.



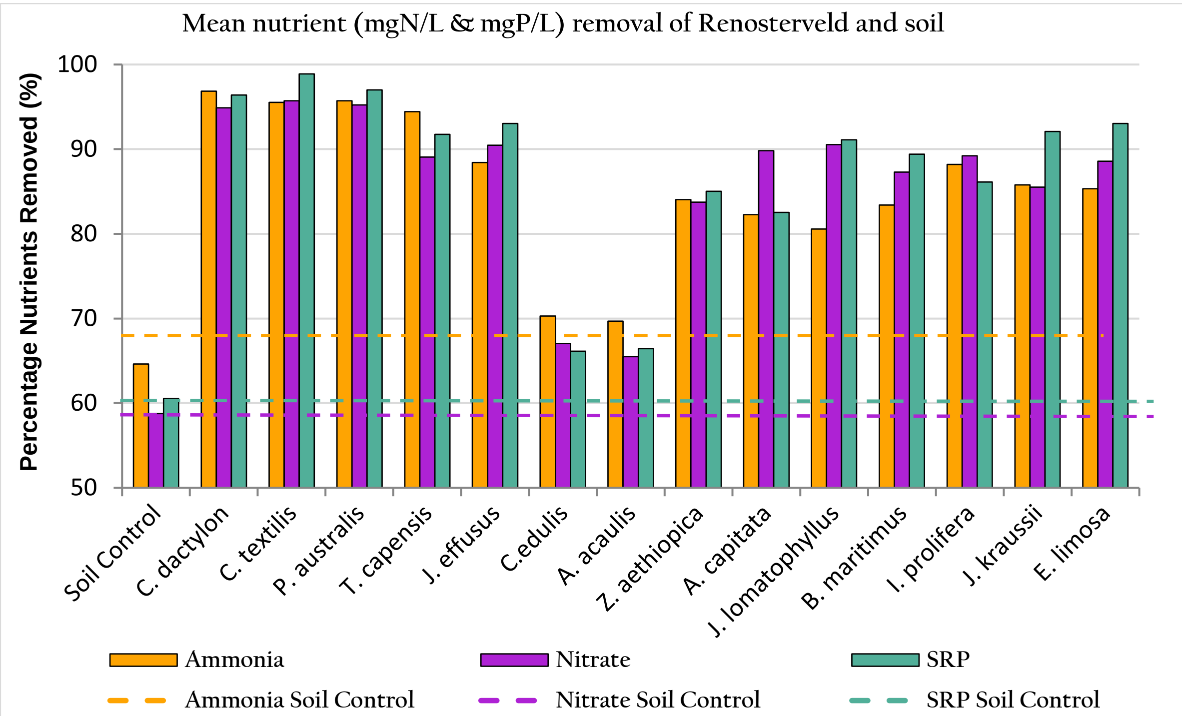
This means that, due to rhizosphere processes, buffer strips are significantly more effective in protecting watercourses, than unvegetated fallow areas. It is evident that the nutrient removal efficiencies improved with time for the duration of the study.

Similar to the removal of fertiliser nutrients, Renosterveld vegetation removed more glyphosate, compared to soil. Although unvegetated soil removal is very high, vegetation remediated pollutants more effectively for both glyphosate concentrations.



It is evident that, the removal rate of unvegetated soil dropped with time, indicating vegetation to remediate herbicide contamination more effectively over an extended period. Concluding that, in the absence of vegetation, herbicide accumulates, resulting in increased leaching and transportation of glyphosate. Environmentally, this may result in increased pollution of adjacent freshwater aquatic systems.

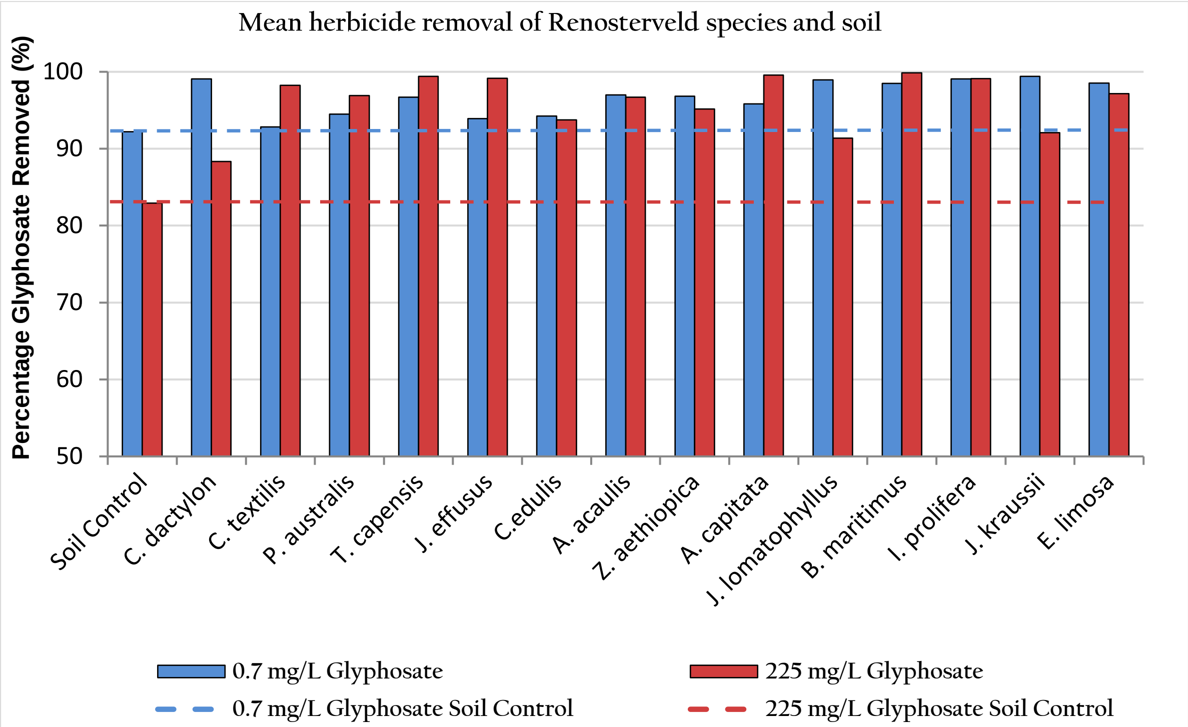
Establishing species specific pollutant remediation, individual species were analysed.



The Renosterveld species displayed exceptional nutrient removal with percentage removal >80%, except for two; *Carpobrotus edulis* and *Arctotis acaulis*. As with collective Renosterveld vegetation, the individual species were all found to be more effective than unvegetated soil. For ammonia remediation, the most effective species, were on average 31% more effective than the un-vegetated soil.

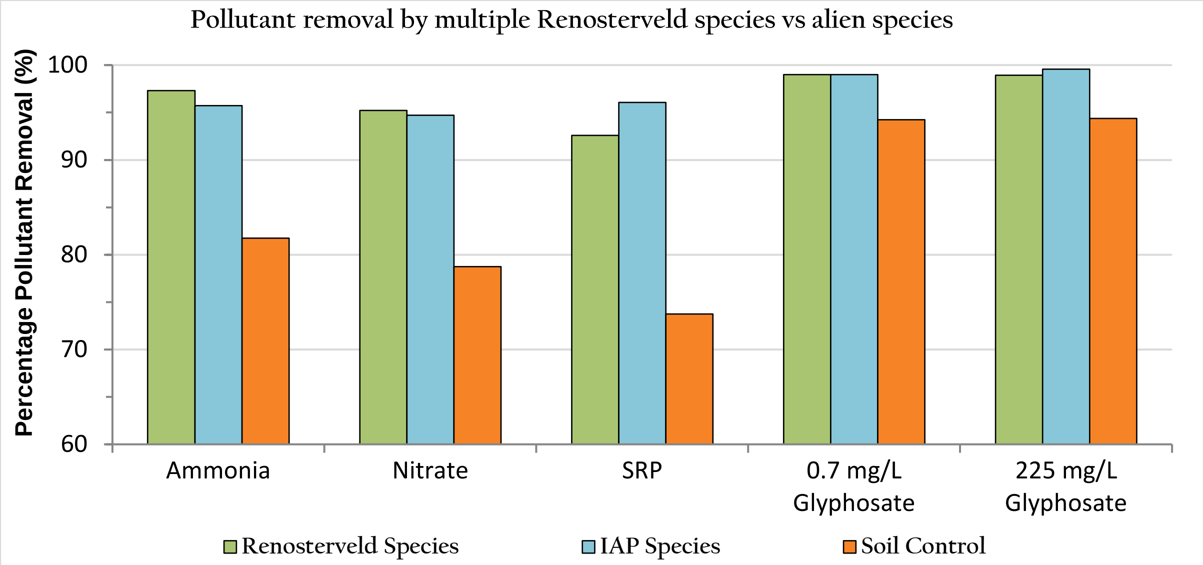
Whereas in the case of nitrate and soluble reactive phosphorous, were on average 36% more effective. The identity of the three most effective species were consistent across all nutrient parameters, with *Cynodon dactylon*, *Phragmites australis* and *Cyperus textilis* all present.

For the herbicide dosage experiment, the individual plant species reduced the 0.7 mg/l glyphosate by 95%, with unvegetated soil removing on average 92%. Similar to the remediation of the less concentrated glyphosate solution, Renosterveld removed 92% of 225 mg/l glyphosate with unvegetated soil on average removing 83%.



Both Renosterveld vegetation and the unvegetated soil displayed exceptional glyphosate remediation. It is noted however that all 14 Renosterveld species displayed greater removal efficiencies than the unvegetated soil, over both concentrations. The majority of glyphosate is reduced by soil media, with vegetation adding to pollutant extraction. This reiterates the importance of the soil media as a role player in the removal of glyphosate.

The community comparison study, evaluated and compared the remediation of Renosterveld plant species and alien invasive plant species currently implemented in SuDS, constructed wetlands and biofiltration treatment trains.



From the data, we can infer that one community is not more effective in pollutant remediation than the other. It is however evident that the Renosterveld and alien communities were more effective than un-vegetated soil. This finding was further supported by a t-test, evaluating the relationship between the three media.

Percentage removal differences between media				
Comparison	**Pollutant**			
	NH_3	**NO_3^-**	**SRP**	**225 mg/L Glyphosate**
Renosterveld VS soil	0.000523	0.00394	0.0136	0.00829
IAP(alien) VS soil	0.00147	0.00282	0.0031	0.00495
Renosterveld VS IAP(alien)	0.233	0.463	0.216	0.135

From the t-test, pollutant remediation by the vegetative communities were statistically significantly different (P-value ≤0.05), compared to unvegetated soil. The p-values, generated by comparing indigenous and alien vegetation are >0.05 across all pollutant parameters, meaning that the two vegetation types are very similar with regard to pollutant extraction and degradation. Concluding that, one community is not significantly more effective in removing pollutants than the other, allowing indigenous species to be implemented instead of their more invasive alien counterparts.

To conclude, comparing vegetation and soil indicated all indigenous Renosterveld plant species to display greater pollutant remediation. However, soil media contributed significantly towards pollutant removal, and in all cases remediated the pollutants to an extent. The indigenous and alien community comparison, found them to exhibit equivalent remediation across all pollutants. Both displaying exceptional phytoremediation, indicates that invasive alien plants can be substituted with less invasive indigenous plant species without losing remediation efficiency. This in turn contributes to the conservation of endangered vegetation, by increasing the natural biodiversity of an ecoregion. The temporal trend analyses further indicated that the plants under study did not alter remediation rates for the duration of the experiment, and that root length correlates to bioremediation.

Implementing indigenous plant species, that include excellent and poor pollutant remediators, creates a mutualistic relationship. The vegetation hinders surface and subsurface flow rates, establishing ideal conditions for nutrient sorption to roots, where N, P and Glyphosate are extracted, translocated, metabolised or volatised by plants.

The proposed vegetative buffers for river corridors adjacent to cultivated land, will extract pollutants from runoff prior to pollutant deposition into watercourses. Further improving water-quality, restraining cyanobacterial bloom establishment, with eutrophication and salinization processes regulated.

Thus to conclude, evidence suggest that ecological infrastructure has the capability to remediate a variety of pollutants, ameliorating a limited freshwater supply. Phytoremediation must and has truly become a proven technology of choice.