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Sunflowers (*Helianthus annuus* L.) on Top of a Constructed Wetland as an Engineered Ecosystem to Clean Sewage Onsite

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Abstract:

The three main components of chemical fertilizers for field crops are nitrogen, phosphorus, and potassium, and they are considered limiting factors to plant growth. The concentration level of these macronutrients on treated wastewater effluents is considered appropriate to support crop production. The purpose of this case study was to use a real-scale model to treat and reuse sewage onsite using a recirculating vertical flow constructed wetland (RVFCW) as an engineered ecosystem planted with sunflowers (***Helianthus annuus* L.**). Effluents from both the septic tank and the RVFCW were analyzed for water quality variables. Treatment efficiencies (removal) were high for fecal coliform bacteria (98%), biochemical oxygen demand (98%), ammonium-nitrogen (97%), total Kjeldahl nitrogen (96%), total suspended solids (92%), total nitrogen (77%), and total phosphorus (76%), while they were relatively low for potassium (38%). These results show that sunflowers growing on top of the RVFCW could be a sustainable alternative technology and a green mechanism to remove pollutants from sewage. A nutrient recovery through the direct use of sewage as fertilizer and water reuse is feasible.

Keywords:

Constructed Wetland; Fertilizers; Helianthus Annuus; Recycling; Sewage; Sunflowers; Vertical Flow

1. INTRODUCTION

The three main components of most chemical fertilizers for field crops are nitrogen (N), phosphorus (P), and potassium (K), and they are considered limiting factors to plant growth. The concentration level of these macronutrients (N-P-K) on treated wastewater effluents is considered appropriate to support crop production [1]. Also, constructed wetlands are considered a viable green alternative to remove not only conventional pollutants from septic tank effluents [2], but also emergent pollutants such as drug residuals, hormones, and personal care products [3]. The treatment performed by vertical constructed wetlands using recirculating flow can reach over 99% removal efficiency for typical contaminants before land application and surface or underground effluent discharges. Garcia-Perez *et al.* [4] suggested that a practical and, environmentally green application for recirculating vertical flow constructed wetlands

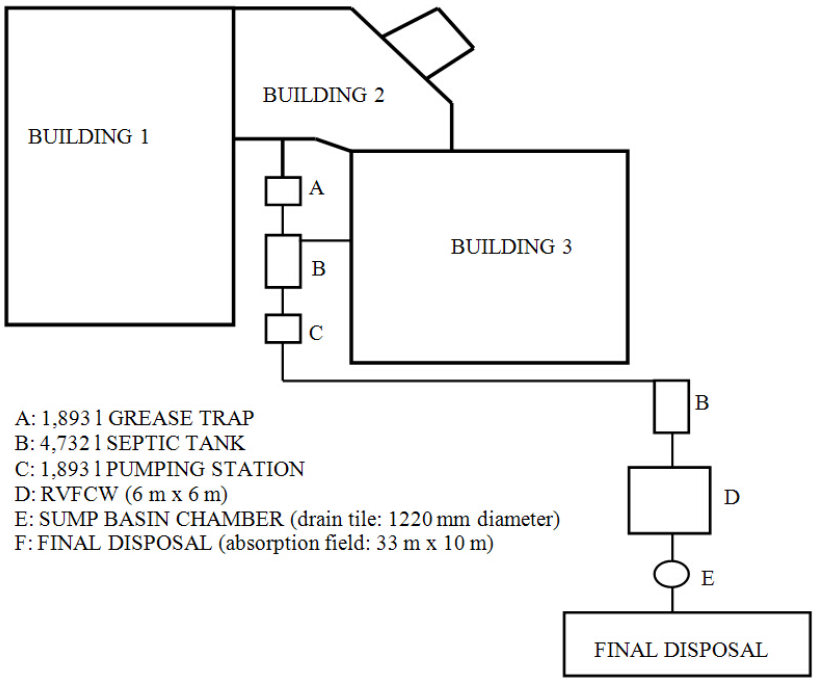

Figure 1. Schematic diagram of the wastewater treatment system. Not to scale.

Garcia-Perez *et al.* [7]. Also, the LaGrange County Health Department has available a public webpage (http://www.lagrangecountyhealth.com/Pages/ConstructedWetlands.aspx) providing photos, general information, guidelines for installation, recommended plants, education material, research references, and an operation and maintenance manual of constructed wetlands to treat sewage onsite.

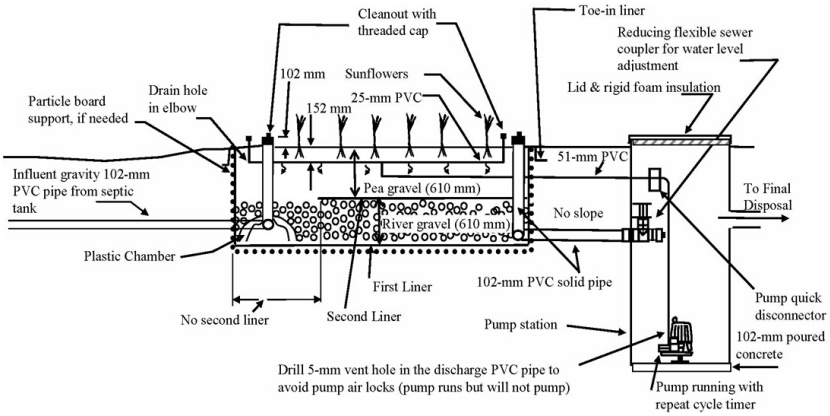

Figure 2. Cross sectional view of the recirculating vertical flow constructed wetland.

Effluent from the constructed wetland was collected in a sump basin chamber. The basin has a double function, as it can be used for the adjustment of the RVFCW water level, if necessary and also contains one or two pumps depending of the local terrain configuration. The basin consisted of a 1520-mm-long section of a 1220-mm-diameter black corrugated drain tile installed vertically to house two submersible pumps: one pump recirculated effluent back to the top of the wetland and another pump fed the treated effluent to the absorption field for final disposal. A concrete layer was placed under the bottom of the

Figure 3. Cycle of the sunflowers crop on top of the constructed wetland treating sewage onsite.

removal.

Plants require more potassium than any other nutrient, with the exception of nitrogen. Potassium in septic waste and sewage sludge is considered to be high [1]. Constructed wetlands effluent should provide enough potassium to meet the requirements for plant growth. Bustamante *et al.* [22] indicated that potassium had no significant effect on organic load removal or in nitrogen elimination from a vertical flow constructed wetland, although potassium is important for plant growth. Vymazal and Sveha [23] showed that CWs with horizontal flow are not effective in removal of alkali metals, reporting low (11%) potassium retention and sequestration by typical CWs plants: *Phragmites spp.* and *Phalaris spp.* Also, studies by Hawkins *et al.* [24], and Maine *et al.* [25] reported low values (¡6%) removal of potassium by CWs. The efficiency of potassium removal reached in this case study (38%) is higher than the 36% reported by Samecka-Cynerman *et al.* [26] and lower than the 49% reported by Garcia-Perez *et al.* [5] planting corn on top of an RVFCW.

The success showed with this case study has the potential to impact any community looking to reduce the health problems created with untreated sewage both in developing and developed countries around the globe. Recirculating vertical flow constructed wetlands could be an alternative method to produce primary feedstock, sunflowers in this case, and clean sewage at the same time. This project could contribute to the recently developed concept of water recycling and nutrients conservation as the new standard for future wastewater treatment systems. Sewage nutrients in constructed wetlands have the potential to be used as alternative technology to grow primary feedstock for biofuel, produce biomass for green energy generation, or feed domestic animals.

The fundamental key of the feedstock model is to create an environmentally balanced management of the treated wastewater to maximize its use before clean water; if any at all, is finally discharged back to surface or underground areas resulting in the lowest possible economic and environmentally negative impacts to local communities. This model to treat wastewater using sunflowers could be a good concept to help in the development and engineering of the next generation of sewage treatment, which should use very low energy input and, recycle nutrients, preventing the degradation of surface water, and the contamination of drinking water supplies. Also, a closed-loop sewage treatment with zero effluent