4.4. Phosphorus Removal and Harvesting from Agricultural Dairy Effluents

Summary: PhosphoReduc filter system is a"closed loop" gravity fed passive filtration system for P harvesting/removal, re-use and recovery. The technology was developed as an outcome of a decade (1999 – 2009) of research by Drizo and co-workers on the use of steel slag aggregates (SSA) for P removal from wastewaters (Weber et al, 2007; Drizo et al, 2008; Bird and Drizo, 2009; Bird and Drizo, 2010; Drizo, 2012). They were among the first researchers who conducted series of field-scale investigations on the potential of SSA for P removal from a variety of wastewater effluents (dairy, barnyard runoff, surface and subsurface agricultural drainage, urban stormwater runoff, industrial sites runoff and sewage). (Drizo and Picard, 2014; Drizo, 2019; WSSI, 2019).

Operation and Maintenance: PhosphoReduc system is a passive treatment system consisting of one or more filter units filled PhosphoReduc filtration media (PRM). Portion of the media needs to be excavated and replaced every 7-10 years (depending on the P cocnentrations in the influent). It is a user friendly system which does not require any mechanical or moving parts, nor electrical components. Therefore it has minimal annual operational and maintenance (O & M) requirements for the owner. O&M consists of the visual inspection of filters for signs of scum formation or preferential flows.

Efficiency:

- Up to 95% Phosphorus removal
- Up to 90% Pathogens removal
- Up to 90% Solids removal

General Criteria Applicable to All Purposes

- Design the system to achieve a reduction in P concentration of the water flowing through the system (Drizo, 2019)/
- Provide a hydraulic retention time (HRT) sufficient to achieve the planned reduction in P concentrations.
- Determine the system size and configuration using the design procedures based on the design flow rate, permeability of the media, P retention capacity of the media and the desired HRT.
- Use geotextile lining, sediment basin or a vessel to prevent the migration of soil particles into the system.
- Media P retention capacity of at least 0.50 percent by weight of materials.
- Ensure that the particle diameter of the media provides sufficient permeability for the flow.
- The material should be recyclable and/or disposable when it has used up its P removal capacity.
- Restore the pH of the discharge water leaving the treatment to acceptable levels.
- Use media for restoring pH levels that is recyclable and disposable, according applicable permits, when it has used up its pH restoration capacity.

Ability for climate chance mitigation: Drizo is currently developing novel designs so that the system can also be used for water retention (and floods mitigation). Also vegetated with local grasses and shrubs, P removal system can contribute to both N_2O and CO_2 emissions mitigation.
Potential for nutrient recovery: Spent P media used in filters can be reused act as a slow release P fertilizer in forestry, acid mine drainage, horticulture (Drizo, 2019; WSSI, 2019).

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Evidence of Success:

2004-2008

Phosphorus Reduction from mixed barnyard runoff and milk parlor effluents, VT, 4 different projects
Average TSS concentration 800 mg/L
Average TSS reduction > 90%
Average influent dissolved P concentration ~ 25 mgP/L
Average dissolved P reduction efficiency > 95%
Average TP concentration ~ 32 mgP/L
Average TP reduction efficiency > 90%

2006-2008

Phosphorus Reduction from milk parlor effluent, Paul Miller Dairy Farm, Burlington, VT
Average TSS concentration 3400 mg/L
Average TSS reduction > 75%
Average influent dissolved P concentration ~ 42.5 mgP/L
Average dissolved P reduction efficiency > 85%
Average TP concentration ~ 55 mgP/L
Average TP reduction efficiency > 85%

2008 – 2010
Phosphorus and E.coli Reduction from mixed barnyard runoff and milk parlor effluents, Paul Miller Dairy Farm, Burlington, VT
Average influent dissolved P concentration ~ 52 mgP/L
Average dissolved P reduction efficiency > 85%
Average TSS concentration ~ 1470 mgTSS/L
Average TSS reduction > 75%
Average influent E.coli ~ 2,646,500 MPN
Average E.coli reduction > 88%

2011-2012
Phosphorus and TSS Reduction from Cheese Processing Effluent, Swanton, VT
Average influent dissolved P concentration ~ 20 mg/L
Average effluent dissolved P concentration ~ 0.23 mg/L
Average TP influent concentration ~ 25 mg/L
Average effluent TP concentration ~ 1 mg/L
Average TSS concentration ~ 120 mg/L
Average TSS reduction > 80%

Cost: The cost of filters depends on the volumes of wastewater that need to be treated, influent and effluent P concentrations and availability of the SSA filtration media. Majority of the cost is for media transportation (generally 40 euros/ton). The initial capital costs for larger filters (flows 60-150 m3/d) can be high. However, the filter has a life span of 30+ years and minimum maintenance fee.
In general for base flows of up to 20 m3/d systems design cost is 7,000 USD (6,200 euros), plus the cost of media and transportation and system construction. For greater flows (60-150 m3/d) filter media and transportation costs can reach 35,000 euro, and with the excavation, implementation costs can reach 70,000 euro. However such filter would be able to treat (remove and also provide possibility for recycling) 55,000 m3 of agricultural runoff per year containing 1-40 g P (after manure spreading).

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