

Optimization Model for Alternative Waste Treatment Technologies for Hog Farming Operations

The following is the proposed model, which minimizes cost while attaining a pollutant discharge standard for various hog farming operations.

Minimize:
$$\sum_{F=1}^N \sum_{T=1}^{n_f} C_{f,t} X_{f,t}$$

Subject to:
$$\sum X_{f,t} = 1, \forall f$$

Example instances of the Model:

Instance 1 (i.e. Regional):
$$\sum_{F=1}^N \sum_t (X_{f,t} R_t^p W_f^p) \geq T^p, \forall p, \forall f$$

Instance 2 (i.e. By Unit of Farms):
$$\sum_{f_i, f_u} \left(\sum_t X_{f,t} R_t^p W_f^p \right) \geq T_u^p, \forall p, \forall u$$

Decision Variables:

- $X_{f,t}$ = **X** technology for a specific **farm** $\{ 1, 0 \}$ i.e. this is asking whether a specific technology is in use or if it is not
- R_t^p = percentage **removal** by a certain **technology** of a specific **pollutant**
- W_f^p = **W**aste load of a specific **farm** of a specific **pollutant**
- T^p = **T**arget for a specific **pollutant**
- T_u^p = **T**arget for a specific **pollutant** for a specific **unit** of operations (size-wise)
- $C_{f,t}$ = **C**ost of a specific **technology** for a specific **farm**

This is a Binary Linear Problem because it takes into account the fact that a specific technology exists or it does not (therefore, the 1 or 0 result. If a specific technology is used in a specific farm, then a value of 1 is returned and thus the associated removal rates and cost is added to the total, otherwise the value is 0). No treatment is considered to be a separate technology. What all these mean is that one or more treatment technologies may exist for a specific farm (although unlikely, due to the unrealistic cost that may be accrued).

The different technologies are going to be explicitly described. What this means is that any variation in any one technology is going to be identified as a separate technology all together with a different removal efficiency and cost associated to it. The option of *no-treatment* will be included as a separate technology as well.

Examples of technologies to be included in the model are listed below:

Technology 1 = No treatment

Technology 2 = Constructed Wetland **without** preceding solid separation but **with** anaerobic lagoon preceding the introduction of waste into the wetland

Technology 3 = Constructed Wetland **with** Inclined screen solids separator (i.e. **without** an anaerobic lagoon preceding waste introduction in the wetland)

Technology 4 = Constructed wetland **with** solid separator # 2 (i.e. different technology used for solids separation)

Technology 5 = Sequencing Batch Reactor (SBR) **with** anaerobic lagoon preceding the introduction of waste into the reactor

Technology 6 = Sequencing Batch Reactor (SBR) **without** anaerobic lagoon preceding the introduction of waste into the reactor

etc.