Table 1: Manure composition and properties

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Manure / Element | Dry matter (% wt) | | N (% dry mass) | | P (% dry mass) | | K (% dry mass) | | VS (% dry mass) | | Vbiogas (m3gas/kgVS) | | Density (kg/m3) |
|
| max | min | max | min | max | min | max | min | max | min | max | min |
| Cattle | 10 | 2 | 8 | 4,7 | 1.3 | 0.8 | 10 | 3.3 | 0.8 | 0.8 | 0,3 | 0,2 | 1041.2 |
| Pig | 6 | 2 | 15 | 13 | 2.2 | 1.9 | 8.3 | 3.9 | 0.8 | 0.7 | 0,5 | 0,25 | 1000.0 |
| Poultry | 60 | 30 | 5.4 | 5.4 | 1.7 | 1.7 | 1,2 | 2,3 | 0.8 | 0.8 | 0,6 | 0,35 | 1009.2 |
| Sheep | 28 | 28 | 2,9 | 2,9 | 0.78 | 0.78 | 2.9 | 2.9 | 0.8 | 0.8 | 0,61 | 0,37 | 1009.2 |

Table 2: Set of components

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Components set** | | | | | | | |
| **Number of component** | **Component** | **Number of component** | **Component** | **Number of component** | **Component** | **Number of component** | **Component** |
| **1** | Wa | **12** | O | **23** | K2O | **34** | Cl |
| **2** | CO2 | **13** | N | **24** | CaCO3 | **35** | Struvite |
| **3** | CO | **14** | Norg | **25** | FeCl3 | **36** | KStruvite |
| **4** | O2 | **15** | P | **26** | Antifoam | **37** | MgCl2\_CSTR |
| **5** | N2 | **16** | K | **27** | Fe2SO4\_3 | **38** | NaOH\_CSTR |
| **6** | H2S | **17** | S | **28** | Al2SO4\_3 | **39** | Mg\_CSTR |
| **7** | NH3 | **18** | Rest | **29** | AlCl3 | **40** | Cl\_CSTR |
| **8** | CH4 | **19** | Cattle\_slurry | **30** | MgCl2 | **41** | Struvite\_CSTR |
| **9** | SO2 | **20** | Pig\_slurry | **31** | NaOH | **42** | KStruvite\_CSTR |
| **10** | C | **21** | Poultry\_slurry | **32** | Struvite\_seeds | **43** | FeCl3\_Coag |
| **11** | H | **22** | P2O5 | **33** | Mg |  |  |

Table 3. Recovered P and N yield for different filter media.

|  |  |  |
| --- | --- | --- |
| **Media/Nutrient** | **P (% recovered)** | **N (% recovered)** |
| **Polonite** | 96.7a | 18.0c |
| **Filtra\_P** | 98.2a | 50.0e |
| **Wollastonite** | 51.1a | 70.0d |
| **Dolomite** | 44.0b | 50.0e |
| **Metal\_slag** | 85.6a | 67.0f |

*a: Gustafsson et al., 2008.*

*b Pant et al., 2001.*

c: *Kietlinska and Renman, 2005.*

*d: Lind et al., 2000.*

*e: Aziz et al., 2004.*

*f: Yang et al., 2009*

Table 4.- Operating data of the optimal configuration for each raw material.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **T (ºC)** | **P (bar)** | **Extractions** |
| **Cattle** | **Bioreactor** | 55 | 1 | -- |
| **Gas Turbine** | 2430 (In)  1205 (Out) | 8.2 (In)  1 (Out) | -- |
| **Steam Turbine** | 1000 (T1)  568 (T2)  442 (T3)  41.8 (T4) | 125 (P1)  11 (P2)  5 (P3)  0.08 (P4) | 6.7% to HX7 |
|  | | | |
| **FBR** | 25 | 1 | -- |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **T (ºC)** | **P (bar)** | **Extractions** |
| **Pig** | **Bioreactor** | 55 | 1 | -- |
| **Gas Turbine** | 2430 (In)  1205 (Out) | 8.2 (In)  1 (Out) | -- |
| **Steam Turbine** | 1000 (T1)  568 (T2)  442 (T3)  41.8 (T4) | 125 (P1)  11 (P2)  5 (P3)  0.08 (P4) | 6.7% to HX7 |
|  | | | |
| **FBR** | 25 | 1 | -- |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **T (ºC)** | **P (bar)** | **Extractions** |
| **Poultry** | **Bioreactor** | 55 | 1 | -- |
| **Gas Turbine** | 2430 (In)  1205 (Out) | 8.2 (In)  1 (Out) | -- |
| **Steam Turbine** | 1000 (T1)  568 (T2)  442 (T3)  41.8 (T4) | 125 (P1)  11 (P2)  5 (P3)  0.08 (P4) | 6.7% to HX7 |
|  | | | |
| **FBR** | 25 | 1 | -- |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **T (ºC)** | **P (bar)** | **Extractions** |
| **Sheep** | **Bioreactor** | 55 | 1 | -- |
| **Gas Turbine** | 2337 (In)  896 (Out) | 15.6 (In)  1 (Out) | -- |
| **Steam Turbine** | 769.6 (T1)  439.1 (T2)  329.6 (T3)  73.0 (T4) | 95 (P1)  11 (P2)  5 (P3)  0.35 (P4) | 2.9% to HX7 |
|  | | | |
| **FBR** | 25 | 1 | -- |

Table 5.- Process optimization results for considered manures

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Manure | Power (kW) | Comp Biogas  (CH4/CO2 ratio) | Digestate treatment technology | Product recovered | Biogas/Manure ratio | Digestate/Manure ratio |
| Cattle | 2,612 | 0.816 | FBR struvite | Struvite | 0.0208 | 0.9794 |
| Pig | 2,612 | 0.816 | FBR struvite | Struvite | 0.0208 | 0.9794 |
| Poultry | 31,349 | 0.818 | FBR struvite | Struvite | 0.2499 | 0.7526 |
| Sheep | 14,106 | 0.818 | FBR struvite | Struvite | 0.1217 | 0.8795 |

Table 6.- Biogas composition for considered manures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Manure | CH4 (%wt) | CO2 (%wt) | Water (%wt) | O2 (%wt) | N2 (%wt) |
| Cattle | 0.385 | 0.470 | 0.120 | 0.006 | 0.020 |
| Pig | 0.385 | 0.470 | 0.120 | 0.006 | 0.020 |
| Poultry | 0.385 | 0.470 | 0.120 | 0.006 | 0.020 |
| Sheep | 0.385 | 0.470 | 0.120 | 0.006 | 0.020 |

Table 7: Electricity production cost and NPV for the facility considering different raw materials

|  |  |  |  |
| --- | --- | --- | --- |
| **Raw material** | **Annual Production costs (M€/y)** | **Electricity production cost (€/kWh)** | **NPV** |
| **Cattle manure** | 12.04 | 0.45 | -1.93E+07 |
| **Pig manure** | 12.07 | 0.45 | -1.96E+07 |
| **Poultry manure** | 25.51 | 0.03 | 2.85E+08 |
| **Sheep manure** | 15.53 | 0.10 | 5.46E+07 |