Supplementary Materials

Engineered Biomaterials for Reducing Phosphorus and Nitrogen Levels from Downstream Water of Aquaculture Facilities

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Nomenclature

Indices

a	Set of collection sites
b	Set of conversion sites
bs	Biomaterial storage
c	Set of biomaterial storage sites
col	Collection
d	Set of bio-oil storage sites
di	Distribution
dr	Dryer
e	Set of water treatment sites
gr	Grinding
os	Bio-oil storage
ppb	Parts per billion
pyr	Pyrolysis
t	Set of time

Parameters

C_{C-col}	Annual capital cost of collection ($/yr)
C_{C-bs}	Annual capital cost of biomaterial storage ($/yr)
C_{C-dr}	Annual capital cost of drying ($/yr)
C_{C-gr}	Annual capital cost of grinding ($/yr)
C_{C-os}	Annual capital cost of bio-oil storage ($/yr)
C_{C-pyr}	Annual capital cost of pyrolysis ($/yr)
C_{C-di}	Annual capital cost of distribution ($/yr)
C_{C-wt}	Annual capital cost of water treatment ($/yr)
C_{V-col}	Annual variable cost of collection ($/yr)
C_{V-bs}	Annual variable cost of biomaterial storage ($/yr)
C_{V-dr}	Annual variable cost of drying ($/yr)
C_{V-gr}	Annual variable cost of grinding ($/yr)
C_{V-os}	Annual variable cost of bio-oil storage ($/yr)
C_{V-pyr}	Annual variable cost of pyrolysis ($/yr)
C_{V-di}	Annual variable cost of distribution ($/yr)
C_{V-wt}	Annual variable cost of water treatment ($/yr)
D	Distance (km)
EP	Total pathway eutrophication (kg PO_4 eq.)
EP_{N2O}	Eutrophication potential of N_2O (kg PO_4 eq./kg N_2O)

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EP_P	Eutrophication potential of P (kg PO_4 eq./kg P)
EP_{EF}	Eutrophication potential for all processes (kg PO_4/ton)
EP_{EFN2O}	N_2O eutrophication potential of all processes (kg N_2O/ ton)
EP_{EFP}	P eutrophication potential of all processes (kg P/ton)
ER_{CH4}	Emissions rate of CH_4 (kg CO_2 eq./kg CH_4)
ER_{CO2}	Emissions rate of CO_2 (kg CO_2 eq./kg CO_2)
ER_{N2O}	Emissions rate of N_2O (kg CO_2 eq./kg N_2O)
M_{bc}	Mass of produced biomaterial (metric ton)
M_p	Mass of raw pinewood (metric ton)
MS_{EF}	GHG emissions factor for biomaterial production process (kg CO_2 eq. per ton)
MS_{EFCH4}	CH_4 emission factor for biomaterial production process (kg CH_4 per ton)
MS_{EFCO2}	CO_2 emission factor for biomaterial production process (kg CO_2 per ton)
MS_{EFN2O}	N_2O emission factor for biomaterial production process (kg N_2O per ton)
MS_{GWP}	Biomaterial production GWP (kg CO_2 eq.)
TR_{EF}	GHG emissions factor for biomaterial transportation (kg CO_2 eq. per ton-mile)
TR_{EFCH4}	CH_4 emission factor for biomaterial transportation (kg CH_4 per ton-mile)
TR_{EFCO2}	CO_2 emission factor for biomaterial transportation (kg CO_2 per ton-mile)
TR_{EFN2O}	N_2O emission factor for biomaterial transportation (kg N_2O per ton-mile)
TR_{GWP}	Biomaterial transportation GWP (kg CO_2 eq.)
$\mathrm{U}_{\mathrm{pyr}}$	Annual pyrolysis utilization (metric ton/yr)
U_{dr}	Annual drying equipment utilization (metric ton/yr)
U_{gr}	Annual grinder utilization (metric ton/yr)
U_{wt}	Annual water treatment utilization (metric ton/yr)
U_{os}	Annual bio-oil storage equipment utilization (metric ton/yr)
U_{bs}	Annual biomaterial storage equipment utilization (metric ton/yr)
$\mathrm{U}_{\mathrm{col}}$	Annual handling equipment utilization (metric ton/yr)
U_{di}	Annual distribution utilization (metric ton/yr)
US_{EF}	GHG emissions factor for upstream processes (kg CO_2 eq. per ton)
US_{EFCH4}	CH_4 emission factor for upstream processes (kg CH_4 per ton)
US_{EFCO2}	CO_2 emission factor for upstream processes (kg CO_2 per ton)
US_{EFN2O}	N_2O emission factor for upstream processes (kg N_2O per ton)
US_{GWP}	Upstream processes GWP (kg CO_2 eq.)

Decision Variables

B_{bct}	Integer variable for biomaterial mass from conversion site b to storage site c during time period t (metric ton)
B_{cet}	Integer variable for biomaterial mass from storage site c to water treatment site e during time period t (metric ton)
BN_{cet}	Continuous variable for biomaterial mass from conversion site b to water treatment site e during time period t (metric ton)
O_{bdt}	Integer variable for bio-oil mass from conversion site b to storage site d during time period t (metric ton)
PN_{abt}	Continuous variable for pinewood mass from collection site a to conversion site b during time period t (metric ton)
Z_{abt}	Binary variable for forest residue from collection site a to conversion site b during time period t