Supplementary S2: Enteric fermentation (CH_4 emissions) and manure management (CH_4 emissions, direct N_2O emission, indirect N_2O emission to air, and indirect N_2O emission to soil) of organic and conventional cows

1. Methane emission

1.1 Methane emission from enteric fermentation

$$EF = [GE \times (Ym/100) \times Day]/55.65 \quad (S2.1)$$

where,

EF is emission factor (kg CH_4/head-day),

Ym is methane conversion factor for dairy cow of 6.5 (Table 10.12, Chapter 10, IPCC (2006)),

55.65 is the energy content of methane (MJ/kg CH_4),

Day is the emission factor would be estimated for the day period (day),

GE is gross energy intake (MJ/day), calculation,

$$GE\left(\frac{MJ}{day}\right) = \frac{\frac{NE_m + NE_a + NE_I + NE_{work} + NE_p}{REM} + \frac{NE_g}{REG}}{\frac{DE\%}{100}} \quad (S2.2)$$

where,

DE% is feed digestibility (%) in dairy cattle average of 80% (75%− 85%), (Table 10.4, Chapter 10, IPCC (2006)),

REM is the ratio net energy available in diet for maintenance to digestible energy consumed $[1.123 - (4.092 \times 10^{-3} \times DE\%)] + [1.126 \times 10^{-5} \times (DE\%)^2] - (25.4/DE\%)]$

REG is the ratio net energy available for growth to digestible energy consumed $[1.164 - (5.160 \times 10^{-3} \times DE\%)] + [1.308 \times 10^{-5} \times (DE\%)^2] - (37.4/DE\%)]$

NE_m is net energy for maintenance or ($NE_m = C_f \times (Weight)^{0.75}$),

C_f is coefficients for maintenance, 0.322 for non-lactating cow and 0.386 for lactating cow (Table 10.4, Chapter 10, IPCC (2006)),

Weight is live-weight of animal (kg),

NE_a is net energy for maintenance or ($NE_a = C_a \times NE_m$),

C_a is coefficients for activity, 0 for stall, 0.17 for pasture, and 0.36 grazing (Table 10.5, Chapter 10, IPCC (2006)),

NEi is net energy for lactation or ($NEi = Milk \times [(1.47 + 0.4) \times Fat]$),

Milk is amount of milk produced (kg),

Fat is fat content of milk (%), 3.7% for conventional cow[1] and 3.88 for organic cow[2],

NE_{work} is net energy for maintenance or ($NE_{work} = 0.01 \times NE_m \times Hours$),

Hours is number of hours of work per day (hr/day) or 11 hrs#[35, 36],

NE_p is net energy for pregnancy or ($NE_p = C_{pregnancy} \times NE_m$),

$C_{pregnancy}$ is coefficients for pregnancy, 0 for cattle (Table 10.13, Chapter 10, IPCC (2006)),

NE_g is net energy for growth or ($NE_p = 22.02 \times (BW/C \times MW)^{0.75} \times WG^{1.097}$),

BW is the average live body weight of animal (kg),

C is coefficients with a value of 0.8 for female,
MW is the mature live body weight of an adult female (kg) or 420 kg for conventional cow and 500 kg for organic cow [35, 36],
WG is the average daily weight gain of the animal (kg) from [35, 36],

1.2 Methane emission from manure management

$$CH_4 \text{ (kg/day)} = (VS \times Day) \times (Bo_{(T)} \times 0.67 \text{ (kg / m}^3) \times \sum (MCF_{S,k}/100) \times MS_{(S,k)} \quad \text{(S2.3)}$$

Day is the emission factor would be estimated for the day period (day),
$Bo_{(T)}$ is maximum methane producing capacity for manure produced by livestock category T or 0.13 m^3 CH_4 /kg of VS excreted or (Table 10A.-4, Chapter 10, IPCC (2006)),
$MCF_{S,k}$ is methane conversion factor for manure management system, 1 for daily spread and 5 for solid storage in the range of 26 – 28 ^oC (Table 10A.-4, Chapter 10, IPCC (2006)),
$MS_{(S,k)}$ is fraction of livestock category handled using manure management S, 29% for daily spread and 0% for solid storage in Asia (Table 10A.-4, Chapter 10, IPCC (2006)),

$$VS = (GE_{DIET} \times (1 - DE\%/100) + (UE \times GE)) \times ((1 - ASH)/18.45) \quad \text{(S2.4)}$$

GE_{DIET} is gross energy intake (MJ/day), calculation from equation C2,
DE% is feed digestibility (%) in dairy cattle average of 80% (75%− 85%), (Table 10.4, Chapter 10, IPCC (2006)),
UE is urinary energy fraction or 0.04 for urinary energy excretion by most ruminants (IPCC, 2006),
ASH is ash content of manure or 0.08 for cattle (IPCC, 2006),
18.45 is conversion factor for dietary GE per kg dry matter (MJ/kg)

2. Nitrous oxide from manure management

2.1 Nitrous oxide from manure management (Direct emission)

N_2O (kg/year) = (Head × Nex × $MS_{(T,S)}$) × EF_S) × 44/28 (S2.5)

Head is number of animals per each category,
Nex is N excreted (kg/head/year) or (Nex = N excreted rate × Weight × Day),
excreted rate = 0.47 kg N/(Weight × 1,000)·Day ((Table 10.19, Chapter 10, IPCC (2006))
$MS_{(T,S)}$: is fraction of total annual nitrogen excretion for each livestock category T that is managed in manure management system S or 29% for daily spread in Asia (Table 10A.-4, Chapter 10, IPCC (2006)),
EFs is emission factor for manure management system or in conditions of daily speed = 0 and solid storage = 0.005 (Table 10.21, Chapter 10, IPCC (2006)),

2.2 Nitrous oxide from manure management (indirect emission due to volatilisation of NH_3 and NO_X)

N_2O_{VOL} (kg/year) = Head × Nex × $Frac_{GasMS}$ × EF_{VOL} × 44/28 (S2.6)

$Frac_{GasMS}$ is fraction of N loss from manure management system due to volatilisation of NH_3 and NO_X or in conditions of daily speed = 0.07 and solid storage 0.3 (Table 10.22, Chapter 10, IPCC (2006)),
EF_{VOL} is volatilisation factor of 0.01 kg N-N_2O/(kg N-NH_3 + kg N-NO_x volatilisation) (Table 11.3, Chapter 11, IPCC (2006)),

2.3 Nitrous oxide from manure management (indirect emission due to leaching)

N_2O_{LEACH} (kg/year) = Head × Nex × $Frac_{LEACH}$ × EF_{LEACH} × 44/28 (S2.7)

$Frac_{LEACH}$ is fraction of N loss from manure management system due to leaching or 0.3 or in conditions of daily speed = 0.07 and solid storage 0.3 (Table 10.22, Chapter 10, IPCC (2006)),
EF_{LEACH} is N losses by leaching/runoff of 0.0075 kg N-N_2O (kg N leaching/runoff) (Table 11.3, Chapter 11, IPCC (2006)),