

Agroenvironmental Hygienic Pressure Indicators (AHPI): Evaluate the Risk of Zoonotic Bacterial Contamination of Water because of Livestock Production

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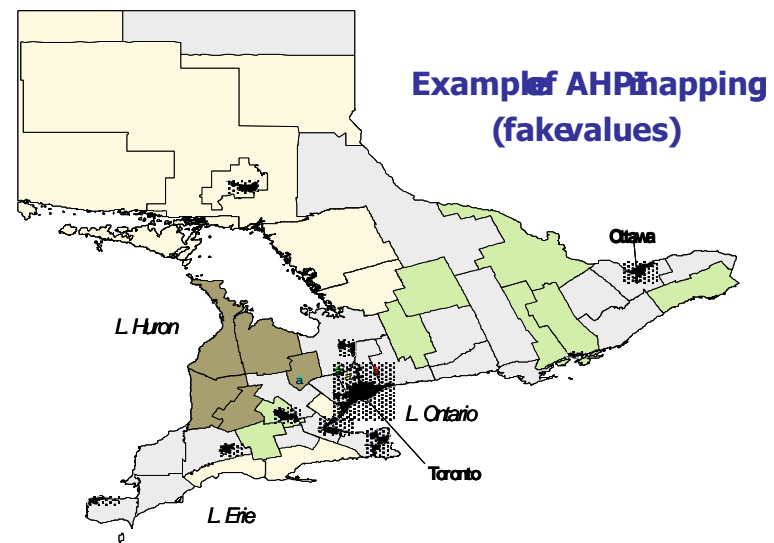
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Microbial Source Tracking Workshop – University of Guelph

April 5th, 2004

AHPI: Main goal

- Assess **risk** of water biological contamination
- tool to manage the risk
- for policy makers and stakeholders:
 - public health
 - agriculture
 - environment
 - citizens



- Different from the bacterial indicators for water quality





AHPI: Development - method

- n based on the modified PICABUE method (Mitchell et al, 1995; Girardin et al, 1999) proposed to develop indicators in the context of sustainable agriculture
- n adapted to bacterial contamination of water in the context of agroenvironment

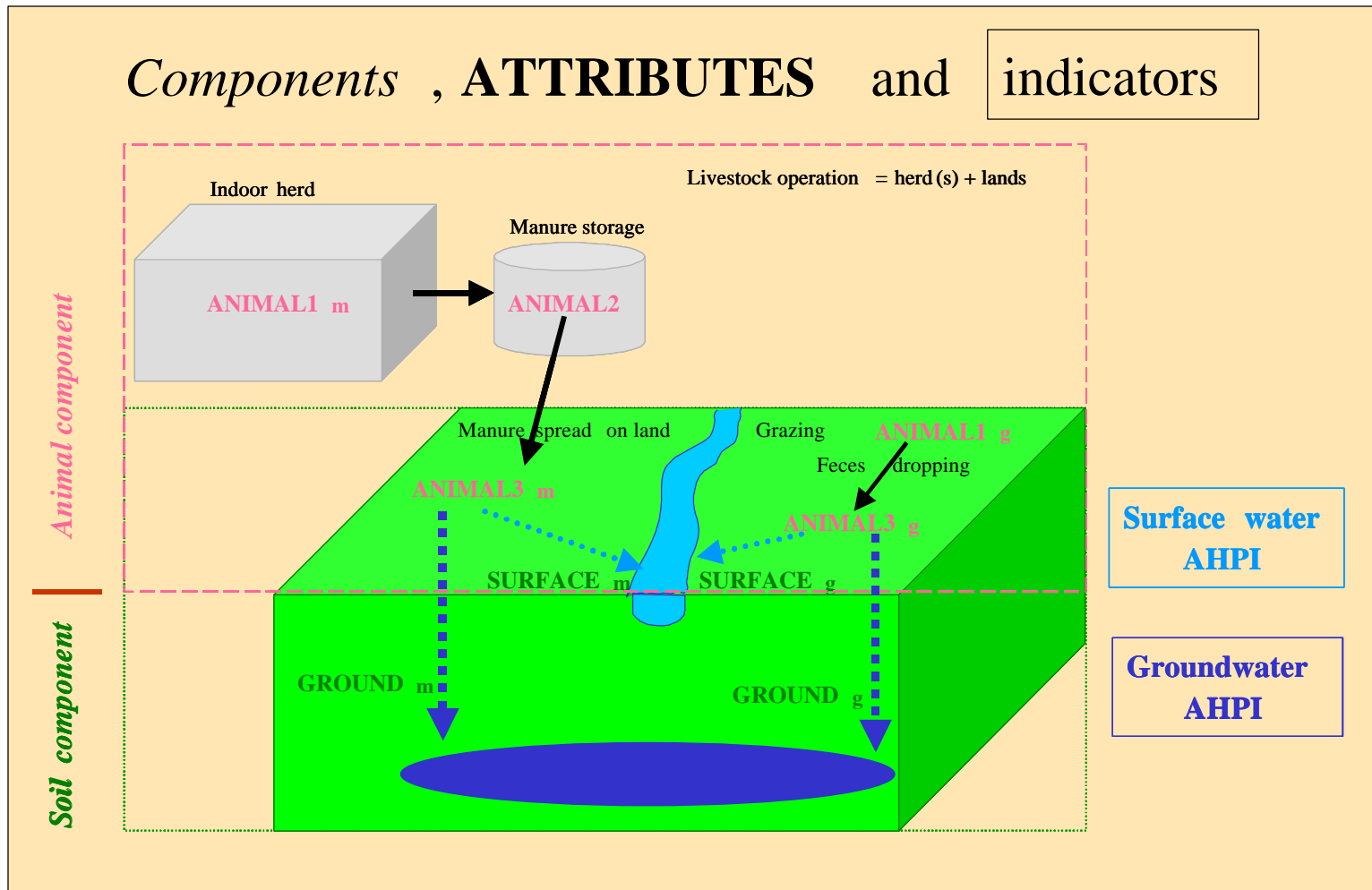


AHPI: Development - objectives

- n considers surface and ground water separately
- n specific to each bacterial species of concern
- n basic space unit: livestock operation (herd + lands)
 - n georeferenced
- n time unit: year



AHPI: Development - objectives



AHPI: Development – input variables

Agro è

Bacterio è

Meteo è

Hydro è

Abbr.	Definition	Unit
Am / Ag	Number of animals producing manure or grazing on pasture	head
Pr	Bacterial true intra- herd prevalence	none
V	Daily volume of fecal matter produced per animal	CFU. ⁻¹
Cex	Concentration of bacteria in feces	none
km	Bacterial die-off rate in manure	days ⁻¹
ks	Bacterial die-off rate on the soil	days ⁻¹
tm	Time of manure storage	days
tg	Time on pasture	days
ibr	Interval between rains during the grazing season	days
inr	Interval of time between manure is spread and the next rain	days
Mr	Proportion of bacteria able to run-off	none
Mi	Proportion of bacteria able to infiltrate	none
Sm	Surface used to spread manure	ha
Sg	Surface used for pasture	ha
ims	Incorporation of manure into to the soil	no=1; yes=0
Rm	Average rain precipitation the months manure is spread on lands	mm
Rg	Average rain precipitation during the grazing season	mm
Cr	Water run-off coefficient	none
Ci	Water infiltration coefficient	none
D	Subsurface drainage	no=1; yes=0
P	Ploughing before spread manure	no=0; yes=1



AHPI: Development – indicator building

Attributes for the animal component

Animal1m	excretion of bacteria by the indoor animals	$= Am \times Pr \times V \times C_{ex}$ (UFC.day ⁻¹)
Animal1g	excretion of bacteria by the grazing animals	$= Ag \times Pr \times V \times C_{ex}$ (UFC.day ⁻¹)
Animal2	bacterial survival during manure storage	$= \int_{t=0}^{t=t_m} e^{-k_m \times t} dt$ (day)
Animal3m	bacterial survival on land after manure spreading	$= \frac{t_g}{ibr} \times \int_{t=0}^{t=ibr} e^{-k_s \times t} dt$ (day)
Animal3g	bacterial survival on land in case of animal grazing	$= e^{-k_s \times inr}$ (dimensionless)



AHPI: Development – indicator building

Attributes for the soil component

Surface _m	bacterial run-off into surface water in case of manure spreading	$= \left(\frac{Mr \times R_m \times Cr}{S_m} \right) \times ims$	(mm.ha ⁻¹)
Surface _g	id in case of grazing	$= \left(\frac{Mr \times R_g \times Cr}{S_g} \right) \times ims$	(mm.ha ⁻¹)
Ground _m	bacterial infiltration down to groundwater in case of manure spreading	$= \left(\frac{Mi \times R_m \times Ci}{S_m} \right) \times D \times P$	(mm. ha ⁻¹)
Ground _g	id in case of grazing	$= \left(\frac{Mi \times R_g \times Ci}{S_g} \right) \times D \times P$	(mm. ha ⁻¹)



AHPI: Development – indicator building

Indicator formulae

for surface water

$$= \sum_{\substack{\text{livestock} \\ \text{operations}}} \sum_{\substack{\text{animal} \\ \text{species}}} \left[\log(\text{Animal1}_m \times \text{Animal2} \times \text{Animal3}_m \times \text{Surface}_m) \right. \\ \left. + \log(\text{Animal1}_g \times \text{Animal3}_g \times \text{Surface}_g) \right]$$



AHPI: Development - example

Variables, components, and indicators				
	unit	dairy cattle ^a		growing pigs
		in barns	grazing	
Variables				
Average number of animals (A)	-	45	15	500
<i>Campylobacter</i> true intra-herd prevalence (Pr)	-	0.6	0.6	0.9
Components				
Animal1	CFU.day ⁻¹	121500000	405000000	113868000
Animal2	day	10.416666		10.416666
Animal3 _m	none	0.1510718		0.1510718
Animal3 _g	day		43.78764	
Surface _g	mm.ha ⁻¹		0.243	
Surface _m	mm.ha ⁻¹	0.024		0.016
Ground _g	mm.ha ⁻¹		0.0567	
Ground _m	mm.ha ⁻¹	0.0056		0.0037
Indicators				
AHPI surface (grazing)	logCFU.mm.ha ⁻¹		10.68	
AHPI surface (manuring)	logCFU.mm.ha ⁻¹	8.662		8.457
Total AHPI surface	logCFU.mm.ha ⁻¹			27.80
AHPI ground (grazing)	logCFU.mm.ha ⁻¹		10.05	
AHPI ground (manuring)	logCFU.mm.ha ⁻¹	8.030		7.825
Total AHPI ground	logCFU.mm.ha ⁻¹			25.90





AHPI: Current Work

- n Sensitivity analysis: which input variables are the most important w/r the AHPI output values;
- n Empirical validation: correlation between AHPI values and bacterial counts in runoff and infiltration water
- n Feasibility: GIS to support AHPI; TOOL
- n Utility for public health : correlation between AHPI values and occurrence of intestinal diseases in humans at regional level