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Microbial sources tracking in recreational water in a leisure center.

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Introduction

Recreational activities on the Champs-sur-Marne leisure area are regularly affected by water contamination issues associated with pathogens of fecal origin. The objective was to identify the origin of these microbes to provide technical development and management solutions favorable to the improvement of the water quality and compatible with bathing activity.

A part of this project was to test the hypothesis of bacteriological contamination by aquatic birds massively occupying the leisure center (fig.1) using a microbial source tracking technique. This approach relies on the quantification by real-time PCR (qPCR) in water, sand, and sediment of bacterial specific markers of the digestive tract of different animal species (geese, seagulls, dogs) and humans.

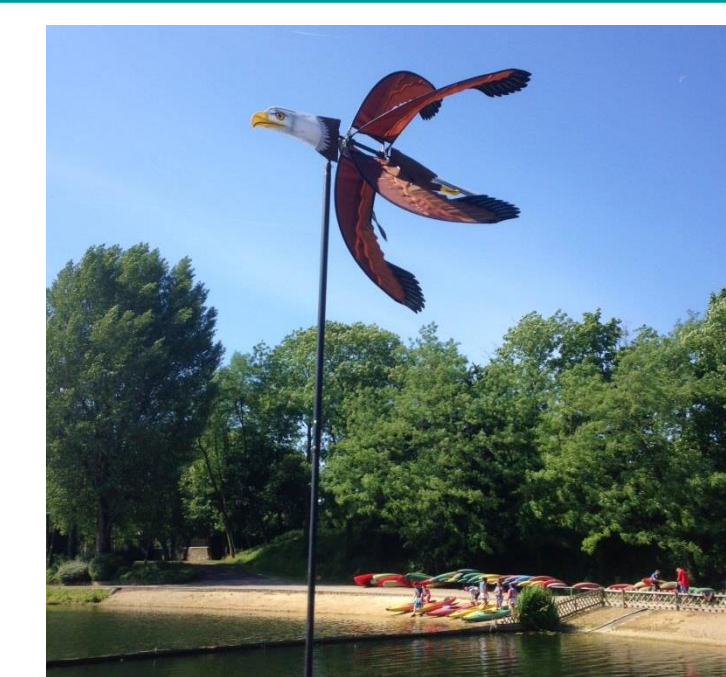


Figure 1: Scarecrow (Eagle) to scare off birds.

Materials and methods

Sampling strategy

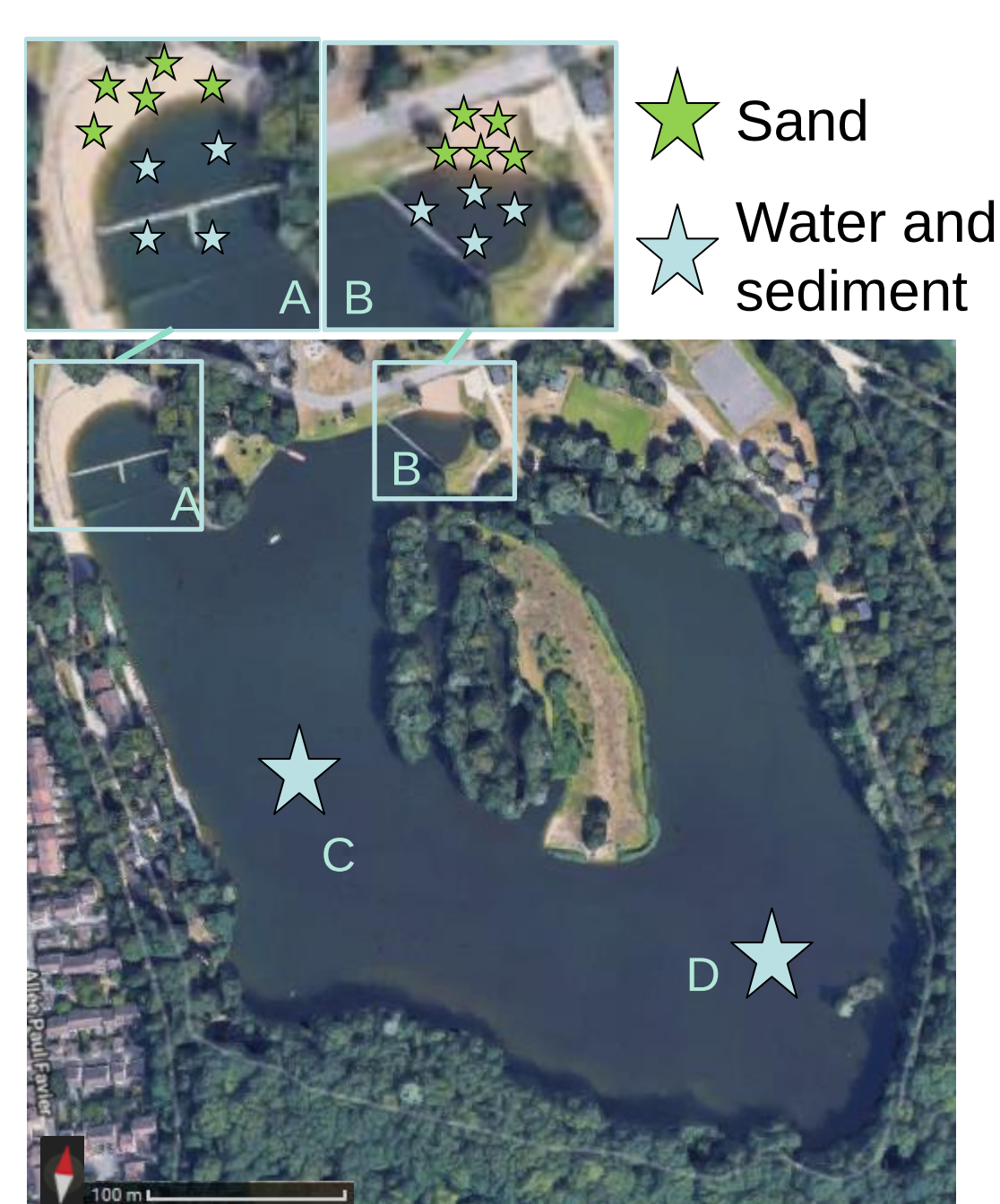


Figure 2: Aerial view of the Champs-sur-Marne leisure lake.

Two sampling campaigns took place in late June and late August 2015 at the bathing areas (A and B) and in the lake (C and D) (fig.2) in 4 replicates: ★

- 2L water for qPCR analysis
- 10L water for virus analysis
- 2x50mL tubes of sediment

In duplicates : ★

- 2 tubes 50mL of mixed sand from quadrat 50x50x1cm on beach

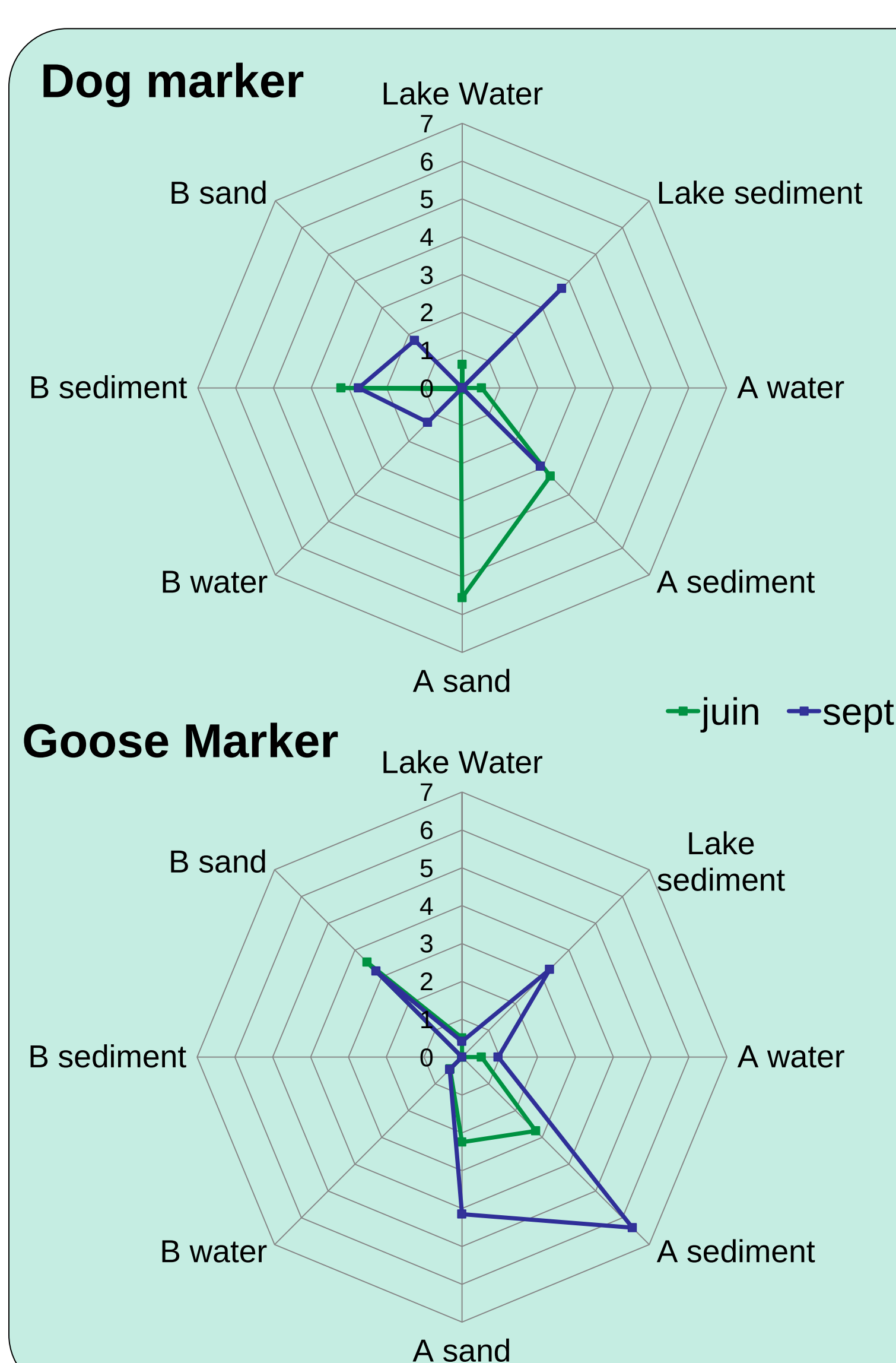
Analysis

Samples → DNA extraction → qPCR

Target	Organism	Gene	Primers 5'-3'	Probe
Dog	Bacteroidales	16S rRNA [1]	GGA GCG CAG ACG GGT TTT CAATCGGAGTTCTCGTGATATCTA	FAM-TGG TGT AGC GGT GAA A-MGB
Goose	Bacteroidales	16S rRNA [2]	GTAGGCCGTGTTTAAAGTCAGC AGTTCGCCCTGCCITGTCTA	FAM - CCG TGC CGT TAT ACT GAG ACA CTT GAG - BHQ1
Seagull	<i>Catellibacter marimammalium</i>	16S rRNA [3]	CTTGCATCGACCTAAAGTTTGGAG GGTTCTCTGTATTATCGGGTATTAGCA	FAM-ACA CGT GGG TAA CCT GCC CAT CAG A - BHQ1
Birds	<i>Campilobacter lari</i>	PepT (pepidase T)[4]	TTAGATGTTGTTGAAATAGCGGAGTT TCAGCTGATTTCCTTAAATTCG	FAM-TGAAAATTGGAAdCGdCAGGTG-BHQ1
Human	<i>Campilobacter jejuni</i>	HipO (Hipurase O) [4]	TGCACCACTGACTATGATAACGA TCCAAATCCTCAGTTGCCATT	FAM-TTGCAACCTCACTAGCAAAATCCACAGCT-BHQ1
Human	Enterovirus, adenovirus, influenza virus A , B	5' UTR Enterovirus Hexon Adenovirus [5] Segment M and NS1 [6]	[5] and [6]	[5] and [6]

For each bacterial target, a plasmid vector was built for the standard curve. Additionally, another plasmid was used as an internal inhibition control. For virus analysis, a control DNA was added to the samples.

Results



Bacterial sources:

- Gull marker was detected only in the water from the large bathing area (A) in September, and in low quantity (less than 3 genome copies per ml).
- *C. jejuni* was detected in just one sample of lake water with a quantity of 0.2 genome copies per ml.
- Dog bacterial marker was detected in most samples with a large quantity range (0.4 to 1.6 x 10⁷ genome copies per ml or g). Dog marker is present in both sediment and sand of the bathing areas, and less in the water. The patterns differ between June (B is more contaminated) and September (A is more contaminated).
- Goose bacterial marker was detected in all types of samples ranging from 1 to 9.4 x 10⁶ genome copies per ml or g. Goose marker was predominant in the sand and the sediment of the large bathing area (A). The pollution was higher in September than in June.
- Dog and goose markers were more present in the lake sediment than the lake water in September.

Figure 3: number of genome copies of dog and goose markers (average Log+1). Lake values are averages of C and D values.

Virus:

- Influenza virus A and B were not detected (qPCR was not inhibited).
- Human enterovirus and adenovirus were not detected in 10L, but some samples were inconclusive (qPCR amplification inhibition).

Conclusions

No contamination by human enteric viruses was found. This suggests that the contamination was not from human origin.

The detection of animal markers in all matrices before and after the swimming season indicates that dogs and geese contribute to the most to the fecal contamination of the water, sand and sediment. The contamination could be originated from two watchdogs roaming around the lake during closing hours, and several geese settled around the large bathing area or on the dock. The fences around the beaches do not stop geese and dogs. Thus, fecal contamination may occur by direct defecation of the birds in the water or by runoff during rain events from the grass, sand and docks.

These results are reinforced with a microbial community analysis where sequencing patterns from the lake samples (water and sediment) and different fecal sources were compared (animal feces, urban waste water, and urban runoff).

[1] Kildare BJ, Leutenegger CM, McSwain BS, Bambic DG, Rajal VB, & Wuertz S. (2007). 16S rRNA-based assays for quantitative detection of universal, human-, cow-, and dog-specific fecal Bacteroidales: a Bayesian approach. Water Res. 41(16), 3701e3715. [2] Fremaux B, Boa T, & Yost CK. (2010). Quantitative Real-Time PCR Assays for Sensitive Detection of Canada Goose-Specific Fecal Pollution in Water Sources. Applied and Environmental Microbiology. 76, 4886–4889. [3] Ryu H, Griffith JF, Khan IUH, Hill S, Edge TA, Toledo-Hernandez C, Gonzalez-Nieves J, & Santo Domingo J. (2012). Comparison of Gull Feces-Specific Assays Targeting the 16S rRNA Genes of *Catellibacter marimammalium* and *Streptococcus* spp. Applied and Environmental Microbiology 78, 1909–1916. [4] Vondrakova L, Pazlarova J & Demnerova K. (2014). Detection, identification and quantification of *Campylobacter jejuni*, *coli* and *lari* in food matrices all at once using multiplex qPCR. Gut Pathogens 6:12-21. [5] Prevost B, Lucas FS, Goncalves A, Richard F, Moulin L, Wurtzer S. (2015). Large scale survey of enteric viruses in river and waste water underlines the health status of the local population. Environment international 79: 42-50. [6] S. Wurtzer, Eau de Paris, personal communication.