Modelling visitor nitrogen waste in coral reefs and implications for the future of sanitation management

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1 Background

- **Poor understanding** of sewage outflow from tourism populations
- Widespread **inattention to sanitation** infrastructure
- Excess influx of nitrogen in sewage threatens **coral reefs**
- **Tourism decreased for multiple years** due to COVID-19

Questions:

- Do **foreign visitors** contribute to coastal sewage output?
- Does foreign visitor sewage affect **water quality**?

Significance:

- Rapid estimation of sewage nitrogen lost to environment
- Highlights overlooked impact of international tourism

2 Methods

- Focused on countries with coral reef hotspots of **biodiversity**, **endemism**, **species richness**
- Curated disparate data on:
  - Tourism, protein availability, sanitation
  - Proportion of inbound visitors that go to the coast
  - Resident population within 10 km of coast, due to high density in this range[1]
- Chlorophyll-a concentration from satellite data within 10 km of coast where sewage impacts are most acute[2]
- Test response of chlorophyll to nitrogen

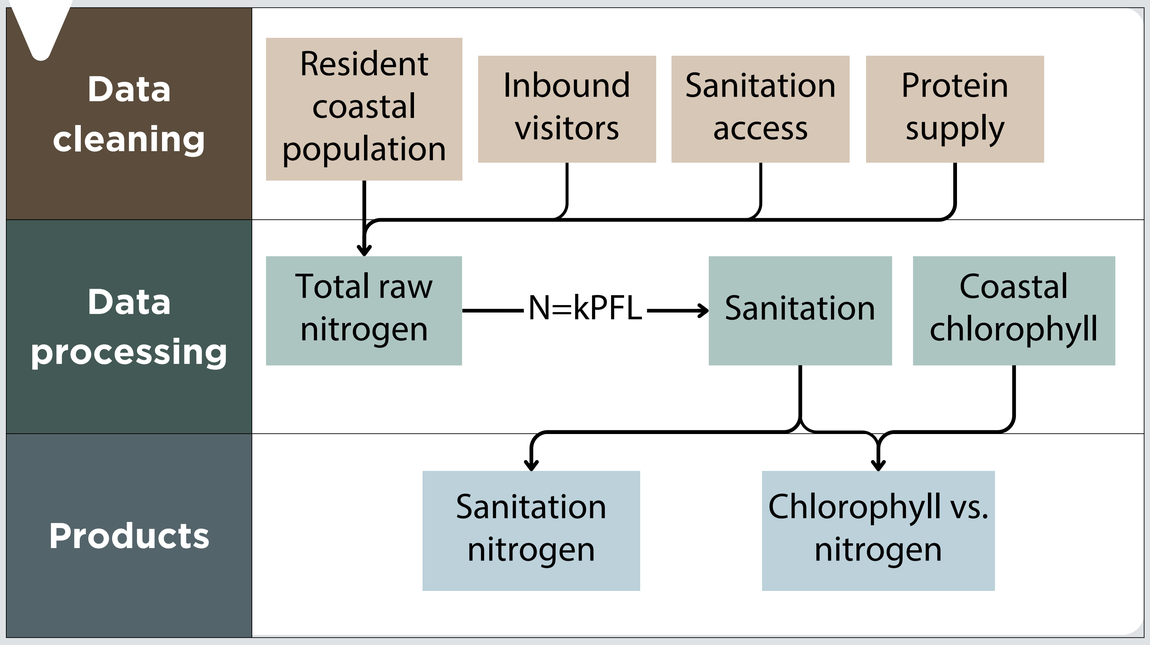

Figure 1. Methods pipeline. **N** is nitrogen lost to the environment (g), **k** is nitrogen excreted from people (g/capita/day), **P** is person-days, **F** is fraction of a population's access to a type of sanitation system, and **L** is nitrogen loss rate of sanitation system

4 Results

Figure 2. The proportion of total estimated nitrogen excretion from inbound visitors in 2019

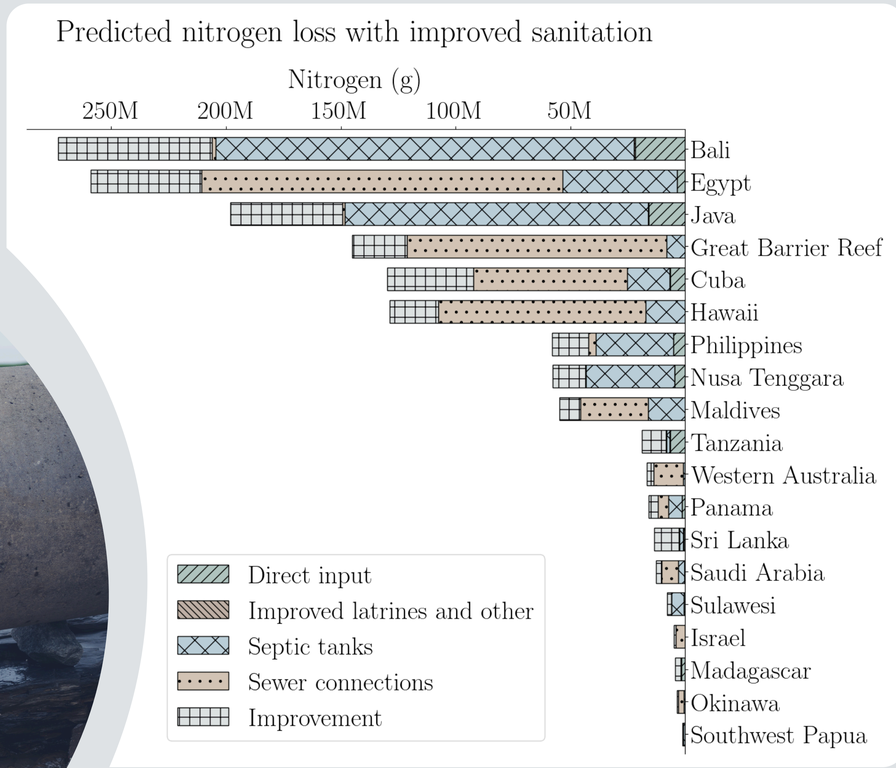

Figure 3. Predicted reduction in coastal wastewater nitrogen (2019) from incremental improvement of sanitation systems. Sanitation classifications adapted from the UN-WHO Joint Monitoring Program

Pandemic's effect on water quality:

Overall, maximum chlorophyll concentration **decreased** after 2020 to the end of 2021 after accounting for combined visitor and resident counts (p-value: 0.0045, AIC score: 590.86)

5 Conclusions

- Visitors can contribute **more than 25%** of wastewater nitrogen
- Negative effects can be mitigated with sanitation improvements
- Pandemic-related travel restrictions reduced chlorophyll concentrations and improved water quality in analyzed regions

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References

1. Sing Wong, A. *et al*., *Global Change Biol*., **28**, 7139–7153 (2022)
2. Savage, C. *Ambio*, **34**(2), 145-150 (2005)