What do Thomas Bayesian, Norwegian Wastewater Infrastructure, Predictive Modelling and Pharmaceuticals in the environment have in common?

I will be doing them a great disservice in the following paper.

# What are the likely drivers of future environmental risk from APIs, for Norway?

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| --- | --- | --- | --- | --- |
| Name | Predictability | ↑ Risk | ↓ Risk | Notes |
| Population change | Good | Increased consumption |  | Off-the-shelf data from SSB |
| Demographic change | Moderate | Increased consumption of old people drugs | Decreased consumption of young people drugs | Off-the-shelf from SSB but different to parameterise |
| Global warming | Moderate | Worse health outcomes drive drug consumption?  Rising water pressures?  Direct & mixture stress? | Lower persistence in environment and WWTPs | Globally well-modelled but less data from Norway, difficult to incorporate complex changes |
| Climate change | Low | More extreme weather = more pulses; may overwhelm WWTPs | More rain = more dilution | Dangerously into the terrain of hydrology, but maybe one could just change dilution factors? |
| Legislative change | Low | May reduce environmental legislation (but probably not) | New green deal, toxic-free environment, One substance, one assessment suggests APIs will be far more scrutinised in future | Very difficult to see how things will unfold, even harder to parameterise. Could be tied in to SSPs? |
| Public attitudes/changes in consumption patterns | Low | Environmental despair, etc. may drive increase in AD and contraceptive consumption | Environmentally conscious consumers may respond to risks posed by APIs | Again, difficult to predict/ parameters, but possibly can be tied in to SSPs. |
| Manufacturing | Low | More manufacturing in Nordic countries may add to risk here | More sustainable manufacturing in other countries may reduce risk of e.g. AMR | Not super relevant to Norway |
| Green chemistry | Low |  | More sustainable drugs may replace existing high-risk APIs | Difficult to parameterise, drug design is a whole can of worms |
| WWTP change | Moderate | If WWTPs get worse, so will exposure | If WWTPs get better, so will exposure. Also affects other stressors | Well studied, I think, and Joanke has worked with various upgrade scenarios |
| Other pollution | Low | Increase in other pollutants will increase overall stress | Vice versa | May be extremely relevant, may also be very out of scope |
| Other ecosystem degradation | Low | As above | As above | Probably a massive contributor, but also out of scope |
| Better risk assessment | Low | “Worse” ERA will reduce protection of environments | “Better” ERA will protect environment better | No idea how to include this, but it seems germane |

Putting all these factors into a Bayesian network is too much work and probably not that informative, but we can, I hope, cherry pick them down to the easiest to implement/most important drivers and model those…

My gut feeling is that it’d be easiest to include **population** and **wastewater treatment**, as they’re easiest to plug into the existing PEC calculation. **Dilution factor** can also be tweaked based on WWTP receiving water, as can **marine assessment factor** if we really want it to.

# What exactly are they driving?

* SumRQ is only appropriate for screening because AFs and chronic/acute toxicity ends up driving a lot of the big big numbers you get out
* SumTU doesn’t have this problem, but requires far more individual EC50s for species & chronic/acute exposures, and can be too granular, making summing difficult
  + Also far more endpoint-based?
* P(RQ > t) doesn’t tell you anything about mixture effects, and is very much driven by choice of (arbitrary) threshold and number of APIs
  + Mind you, so are all the other approaches

# What do you want to recommend?

* Intuitively, probably better WWTP tech/siting
* Do you need to recommend anything?
* Is RQ meaningful in a context where you’re not trying to drop RQ < 1
  + Is it meaningful even then?
* Am I getting overly-fixed on the broader significance of the ecotoxicological equivalent of a sticking plaster?
* How do you demonstrate probabilistic risk without just a probabilistic RQ?
* Wayne’s work with Chinook salmon had a target fish population size, which might be (?) complicated to model but is helpful in terms of actual environmental targets, because as far as I can tell there aren’t any for pharmaceuticals…
* Targeting regulatory requirements feels like a moving target right now, because a) EMA ERA guidelines are laughably behind REACH, etc., b) planned changes in the [Chemical Strategy for Sustainability](https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf) sound very impressive but are a long way from being implemented
* Norwegian nature indices hover around 0.75 for freshwater/coast/oceans, but I don’t really know how I’d tie this to APIs in any meaningful way
  + Could look at the better-studied Oslofjord as a case study, but tying pharmaceuticals to real-world effects is still challenging and
* Random thought: how does the output of [pills and IUDs compare?](https://europepmc.org/article/med/26015090)
  + Followup thought – do you, a dude, want to make a paper recommending everyone get an IUD for environmental reasons… (probably not)
* Of course, if it turns out that levonorgestrel and EE2 have low actual risk based on unconservative PECs/MECs then the central thesis falls apart, but what can you do!?
* Also the Oslofjord plan is in Norwegian, so I don’t really know what those goals are. But I would hope they involve fish!?
* Also levonorgestrel and EE2 are probably so diluted in the Oslofjord as to not pose a real issue…

## This is all probably too ambitious, so instead:

* Poster BN, but
* 2-4 high risk APIs with DRCs/EC50s
* Sales-data based prediction for UK and NO
* WWTP-upgrade scenarios for Norway, and UK if easy to adapt from someone else