WATER ENVIRONMENT + REUSE FOUNDATION WERF Nutrient Challenge

InnovaReg: Innovative Nutrient Regulations for Wastewater Treatment Plants

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Summary

A wide diversity of regulatory practices for wastewater treatment exists throughout the world. This diversity not only reflects the variety of receiving water bodies and their beneficial uses, but also the variety in ways different jurisdictions make regulations operational. This project aims at:

- Providing an overview of the different schools of thought in nutrient regulations.
- Discussing and quantifying the implications of choosing certain nutrient permitting structures, objectives, standards and compliance testing methods for protecting environmental and human health.
- Showing how innovation in the wastewater industry is significantly driven by local regulations, some stimulating whereas others inhibiting innovation and leading to excessive conservatism and cost.
- Running dynamic model simulations for different case studies to better understand the relation between nutrient regulations, WWTP design and environmental protection.

Project Scope

The following project goals have been defined:

- Phase I: Critical survey of nutrient permitting approaches around the world
- Phase II: Get better insight in regulations by comparing legislation through simulations
- Phase III: Propose changes to the US regulatory framework

Key points include:

- Innovation stimulating and limiting aspects of regulations
- Impact of/on wastewater treatment plant design and operation
- Integrated approach: collection system, wastewater treatment plant, receiving water
- Uncertainty: safety factors and conservatism in regulations, permits and design
- Stochastics: variability in treatment plant performance and flow and quality of wastewater and receiving water
- Compliance assessment: sampling, data treatment, criteria

Global Overview Regulations

A literature review and exploratory questionnaire that was sent out to water professionals around the world to gather information on treatment plant compliance assessment (Figure 1) showed there is a shockingly wide diversity in regulations to protect human and environmental health:

- Origin: technology based limits (TBEL) vs. water quality based limits (WQBEL); prescriptive laws vs. water quality simulations and negotiations; sensitive vs. non-sensitive areas; etc.
- Standards: P_{tot} (0.07–10 mg P/L); N_{tot} (3–60 mg N/L); NH_4 (2–20 mg N/L); NO_X (0.3–15 mg N/L)
- Compliance: not specified; grab vs. daily composite sampling; hourly to monthly sampling intervals; weekly to yearly averaging; no exceedance allowed vs. percentile exceedance with the possibility of data exclusion

Compliance assessment	STANDARDS							
	Sampling					Compliance - Data analysis		
	Frequency	Type						
		Grab	Composite					
Country			Length	Sub-sample Frequency	Proportional	Exclusion	Averaging	Exceedance
Argentina								
Australia								
Belgium								
Brazil								
Canada - Ont.								

Figure 1: Overview of questionnaire on treatment plant compliance

EU vs. USA

Both the EU and USA have a very elaborate set of tools to abate harmful nutrient discharges. Some of the key regulation aspects, both positive + and negative -, have been highlighted in the table below:

EU	USA
Good ecological and chemical water status	Protecting beneficial water uses
Explicit mix of TBEL and WQBEL	Main focus on WQBEL +
Flexible on tools to achieve objectives +	Historical strong focus on toxicants -
Obliged international river basin management planning +	Watershed-based permitting when necessary
Full cost recovery through adequate water pricing (polluter pays and proportionality) +	Effluent trading within watershed is encouraged +
Possibility of performance-based permitting through pollution tax +	Anti-backsliding principle -
Compliance allows for exceedances +	No exceedances allowed -
Non-point source nutrient control remains difficult to achieve -	Non-point source nutrient control remains difficult to achieve -

Workshop on Nutrient Regulations

A workshop was held from 19 to 20 October 2015, in Alexandria, VA, USA (Figure 2), discussing:

- The large spectrum of regulatory approaches for nutrients
- Innovation stimulating and limiting aspects of regulations
- Ways to showcase differences in regulatory approaches

Figure 2: Nutrient regulations workshop hosted at WEF's headquarters

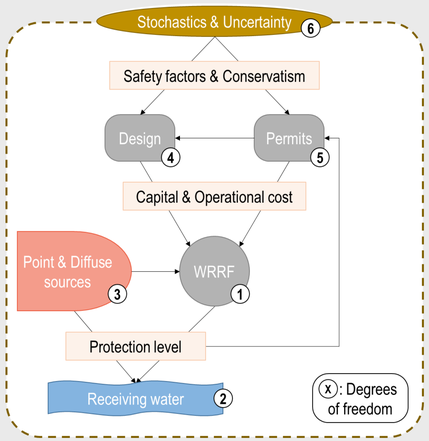
The workshop was attended by 21 water professionals, representing 7 countries and encompassing utilities, academia, regulators, consultancy and advocacy.

Ideal Policy

The principles and tools of several legislative frameworks can be combined into an 'ideal' policy to attain a better overall protection of the environment:

- Nutrients are different than toxicants. Only when all conditions are favorable, eutrophic effects can occur. Nutrient-based responses are slow and temporary exceedances will not invoke an acute-type response. Appropriate discharge permit structures for nutrients should consider:
  1) Long averaging periods
  2) Loads rather than concentrations
  3) Preferential nutrient control
  4) Nutrient speciation and bioavailability
  5) Stochastics of the environment and variability of treatment performance
  6) Effluent trading with regard to non-point sources
- The aspect of innovation is seldom discussed with regards to effluent regulations. Nevertheless, certain conditions can help spawning innovative solutions:
  1) Ambitious environmental objectives that challenge the current technological and organizational boundaries
  2) A flexible legal framework that allows for some freedom in achieving the environmental goals
  3) An appropriate financial framework that incentivizes

Model Case Study



The efficacy of different permit structures will be tested on a virtual but realistic model case study existing out of a standard BNR plant (ASM2d – Henze et al., 2000), discharging into a river stretch (RWQM1 – Reichert et al., 2001). A phenomenological influent generator will provide stochastic input data for a typical sewershed (Talebizadeh et al., 2015). Uncertainty will be introduced via influent, plant design and model parameters. In a later phase a more elaborate case study will be used to investigate permitting options for multiple sources in a watershed as well as the use of advanced and innovative treatment options.

Cited and Recommended Literature

Brown and Caldwell, 2014. Review of USEPA methods for setting water quality-based effluent limits for nutrients. National Association of Clean Water Agencies, Washington D.C., USA.

Clark, D.L., Dupuis, T., Falconer, H., Hatch, L., Kasch, M.S., Lemonds, P.J., Neethling, J.B., 2015. Nutrient management volume III: Development of appropriate permitting frameworks. WERF, Alexandria, VA, USA.

Henze, M., Gujer, W., Mino, T., van Loosdrecht, M., 2000. Activated Sludge Models ASM1, ASM2, ASM2d and ASM3. IWA Publishing, London, UK.

Iho, A., Ribaudo, M., Hyytiäinen, K., 2015. Water protection in the Baltic Sea and the Chesapeake Bay: Institutions, policies and efficiency. Marine Pollution Bulletin, 93, 81-93.

Jacobsen, B.N., Warn, T., 1999. Overview and comparison of effluent standards for urban waste water treatment plants in European countries. Eur. Water Man., 2(6), 25-39.

Novak, P.J., Arnold, W.A., Henningsgaard, B., Hozalski, R.M., Kessler, K., LaPara, T.L., Parrella, A., Rogacki, L., Thompson, C., Thorson, R., Zimmerman, R.A., Bott, C.B, Daigger, G.T., Neethling, J.B., 2015. Innovation Promoted by Regulatory Flexibility. Environ. Sci. Technol., 49, 13908-09.

Talebizadeh, M., Belia, E., Vanrolleghem, P.A., 2016. Influent generator for probabilistic modeling of nutrient removal wastewater treatment plants. Environmental Modelling & Software, 77, 32-49.

Reichert, P., Borchardt, D., Henze, M., Rauch, W., Shanahan, P., Somlyody, L., Vanrolleghem, P.A., 2001. River Water Quality Model No. 1 (RWQM1). IWA Scientific and Technical Report No. 12. IWA Publishing, London, UK.

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