<u>On-Line instrumentation for critical wastewater parameters</u>: *many are available, but few are chosen*

Deon Anderson
MSc. Water & Wastewater Engineering

deon_anderson@yahoo.com

Deon Anderson
MSc. Water & Wastewater Engineering

Background

- Increasingly tight consents regulating effluent discharges from wastewater treatment plants
- Consequently water and wastewater utilities have been continuously seeking to optimise their processes in an effort to meet these consents, while at the same time reduce costs.

Background

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- Fixed dissolved oxygen (DO) concentrations were set to control effluent chemical oxygen demand (COD) and ammonia concentrations.
- Fixed chemical doses were set to maintain effluent phosphate levels below the consent limits.

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Background

- Fixed dosing regimes resulted in an excess of air and chemical supplies respectively during low influent loads, which increases operational costs.
- In many countries, the cost of electricity has doubled over the last 10 years.
- The use of chemicals in wastewater treatment has been competing with that for potable water treatment.

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Background

The main drivers for wastewater treatment therefore involve:

- Reduction of costs associated with energy and chemical consumption
- Meeting effluent consents, while using minimal resources.

Considering these drivers, real time control (RTC) is worth consideration for full scale implementation

Why online instrumentation?

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Nitrification processes:

- Aeration typically constitutes ≈50% of total power consumption.
- Real time measurements and control have proven to **lower** this to **15-28%** by supplying only required amount of DO as demand varies.

Why online instrumentation?

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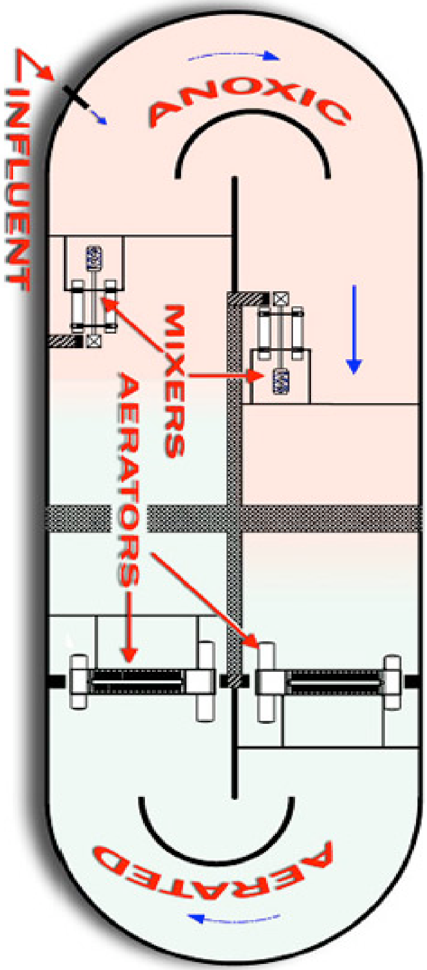
Denitrification processes

- Methanol: external source of carbon for the microbial conversion of nitrate to nitrogen gas.
- Online measurements and control have proven to **reduce** methanol consumption up to **50%** by modulating methanol dose according to incoming nitrate load.



Why online instrumentation?

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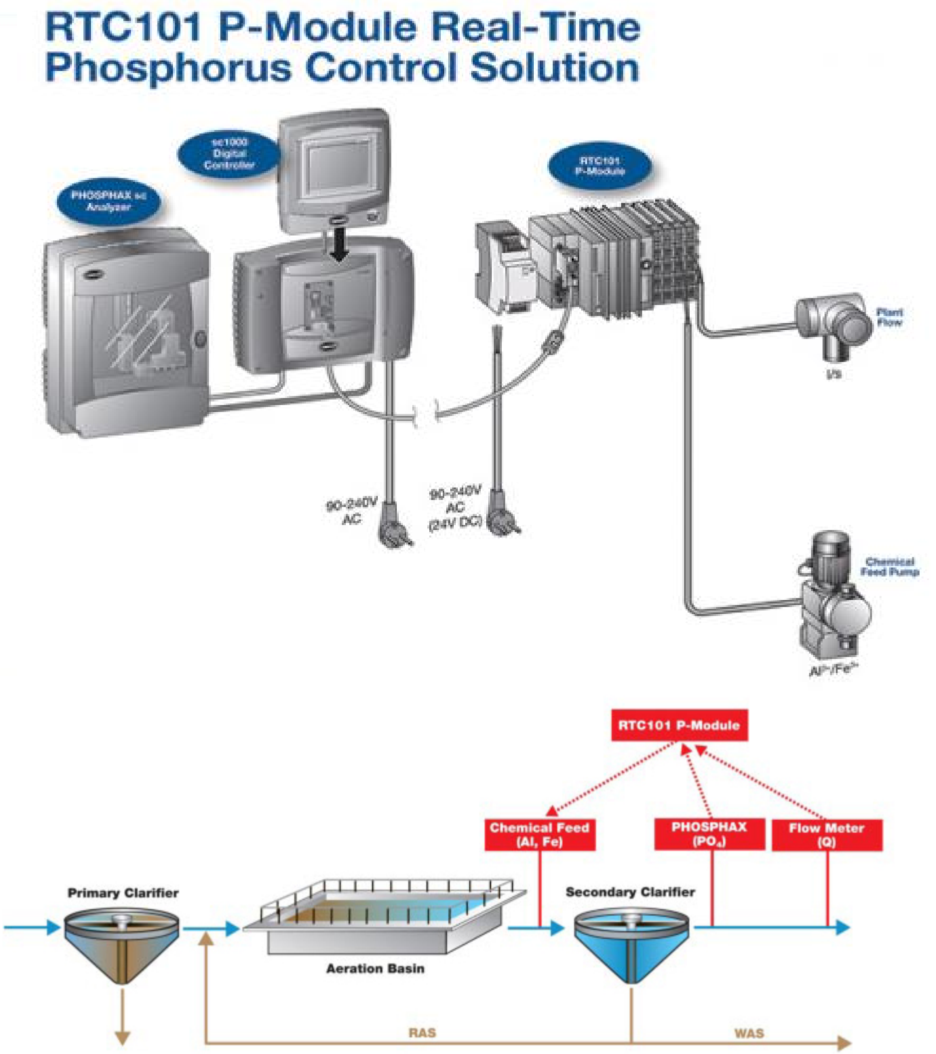
Chemical phosphorous removal

- Metal salts (coagulants): used to remove phosphorous via a precipitation reaction.
- Significant reductions of up to 56% in coagulant consumption with online measurements and control.



Control loop

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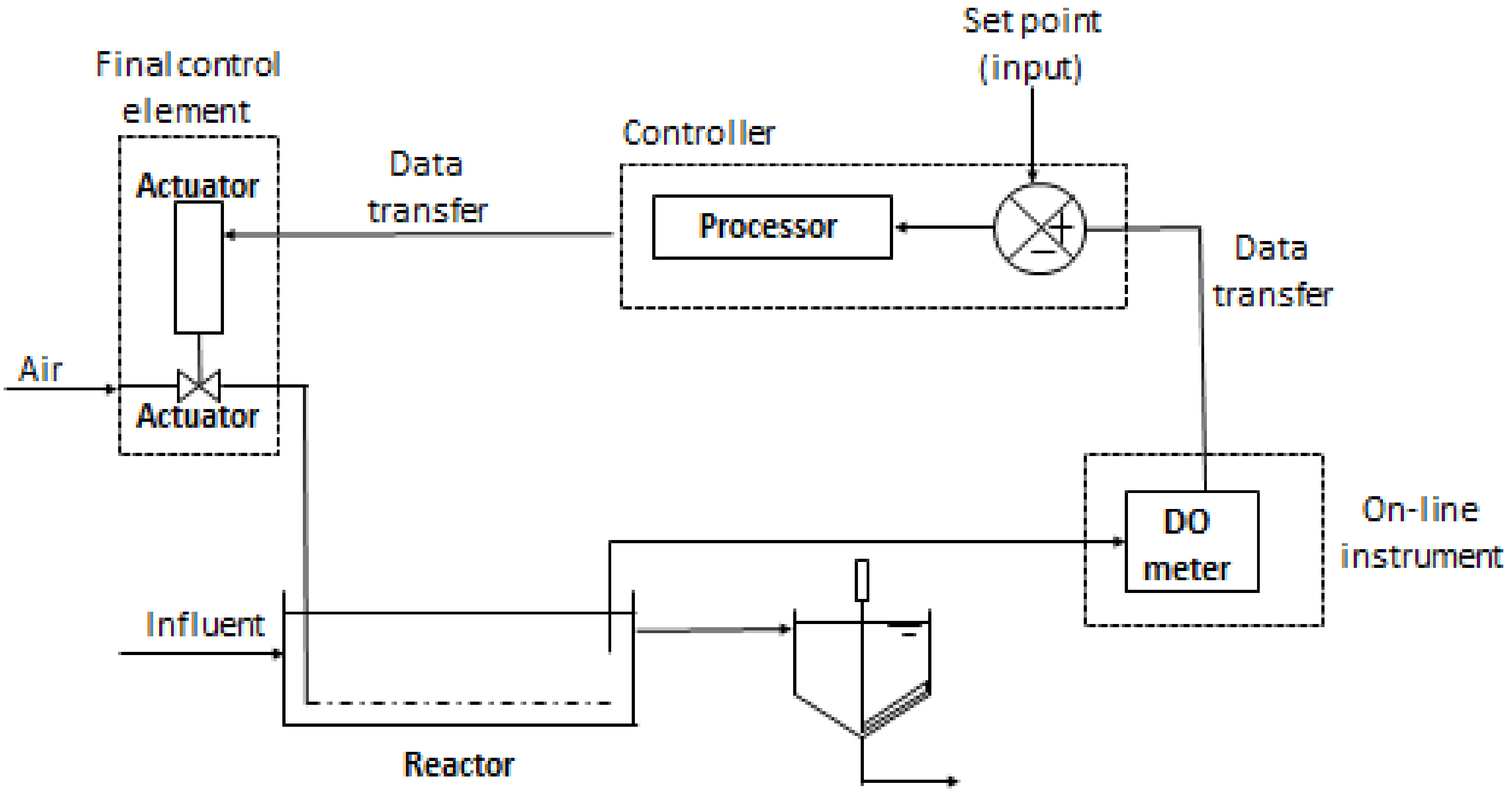

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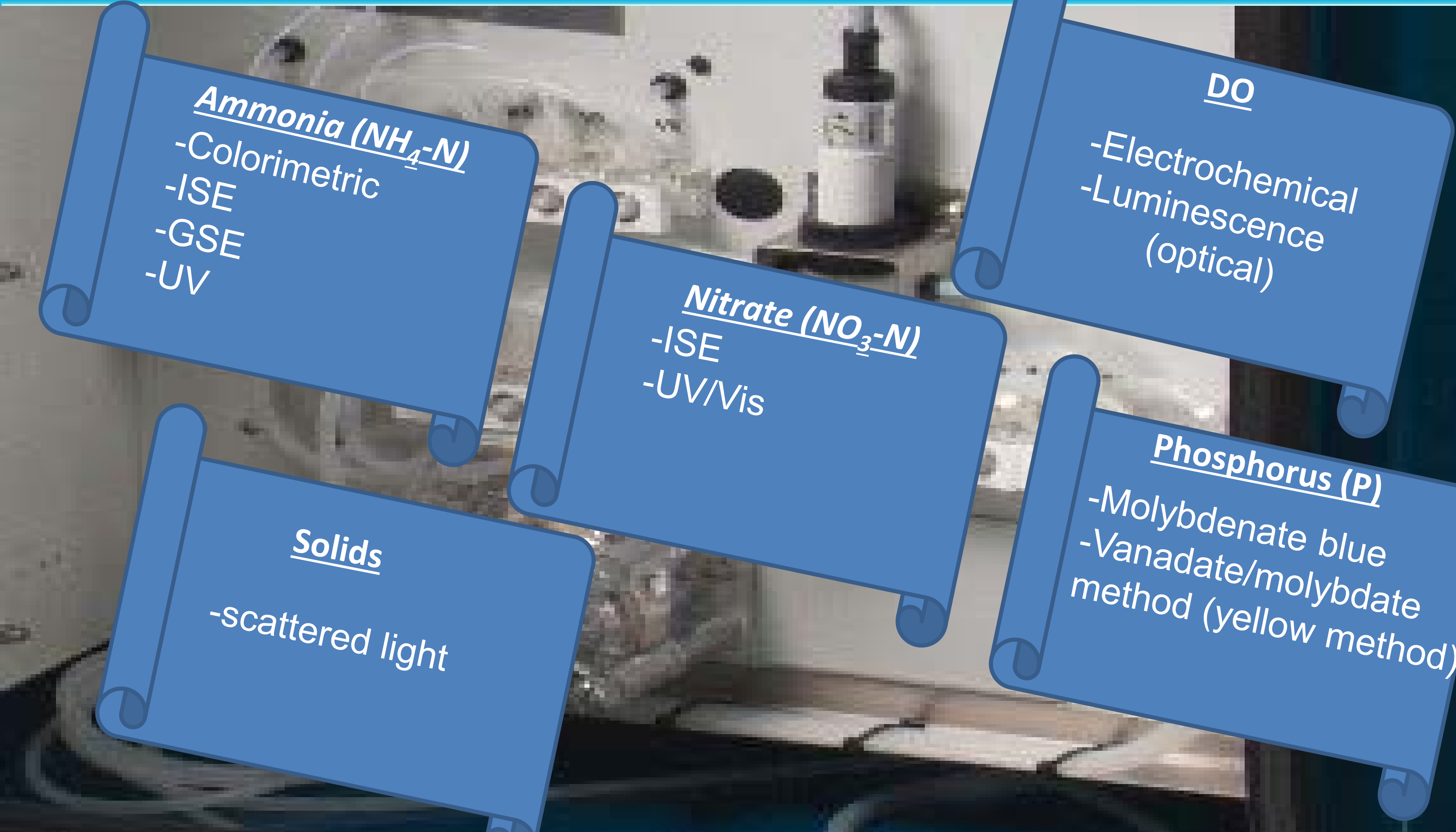
Methods of online measurement



Ammonia (NH_4-N)
- Colorimetric
- ISE
- GSE
- UV

Nitrate (NO_3-N)
- ISE
- UV/Vis

DO
- Electrochemical
- Luminescence (optical)

Solids
- scattered light

Phosphorus (P)
- Molybdenate blue
- Vanadate/molybdate method (yellow method)

Dissolved oxygen (DO)

Advantages	Limitations
Electrochemical method	
Low cost	Susceptible to errors
Gives direct measurement	Membrane fouling
Linear response	Membrane fragile, sensitive.
Adapts rapidly to changing oxygen conc. (approx. 60s for change from 0 to 98% sat.)	Electrodes & electrolytes consumed.
Accurately detects small changes in concentration	Needs re-calibration if temp & pressure significantly fluctuates.
	Often drifts from calibration
	Very long start up time (as much as 6 hrs)
	Maintenance & downtime
Optical method	
Minimum maintenance, robust, reliable and fast.	Response time is slower (for decreasing conc.) than for increasing concentration but overall rapid

Ammonia (NH_3-N)

Advantages	Limitations
Colorimetric	
Accurate	Complexing reagent (citrate, EDTA) needed to avoid precipitate interferences
Follows standard method procedure	Need specialist on site to carry maintenance
	Chemical disposal required
	Frequent clogging of narrow tubings
ISE	
Inexpensive	Precision rarely better than 1%
Simple to use	Electrodes easily fouled by proteins and organic solutes
Wide concentration range (typically from <1 to several thousand ppm)	Interference by presence of other ions
Non consuming, non-contaminating to analyte	Electrodes fragile, have limited shelf life (requires replacement > thrice a year)
Short response time	Electrodes respond to activity of uncomplexed ions (ligands must be masked)
Unaffected by colour or turbidity	Often drifts from calibration
Frequent calibration (every 2 wks or	

Advantages	Limitations
Gas sensing electrode (GSE)	
Not affected by colour, turbidity	Interference from volatile amines
Not affected by presence of other ions or dissolved species	Reagent replacement (but inexpensive)
Electrode can be used in flow through applications	
UV absorbance	
No probes used	Organic substances absorb UV at 254 nm thus can potentially interfere
Accurate	Turbidity can also potentially interfere
	Adjustment mechanisms like multiple wavelength detection needed to compensate for interferences
	Can be expensive

Phosphorus (colorimetric methods)

Advantages	Limitations
High sensitivity	The reagent reacts with phosphorous only in the form of $PO4^{3-}$.
Simple	Due to filtration of sample, other forms of P may be lost with solids.
	High temperature digestion (before filtration) required for total-P
	Phosphate has high affinity to glassware: acid wash of sample cell may be needed.
	Requires constant chemical replacement and safe chemical disposal.

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Case Study

- population served: 484,000 pe
- Regulated consent for total P: 1mg/l.
- Coagulant used: Ferric sulphate primary settlement tanks (PST), which also improves the solids removal in the PSTs
- primary settlement, there are aeration tanks containing anoxic and anaerobic zones, secondary settlement tanks anda sand filter for tertiary treatment of the effluent
- RTC 101-P

Influent flow and P-concentrations

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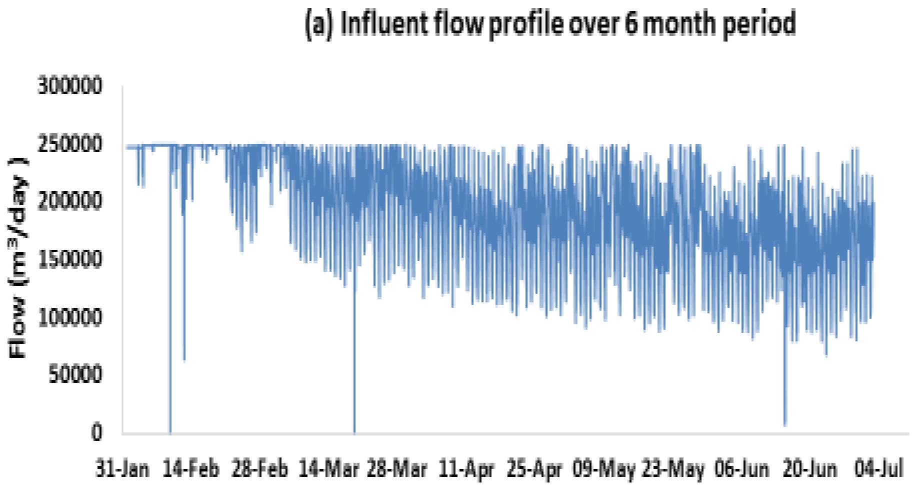

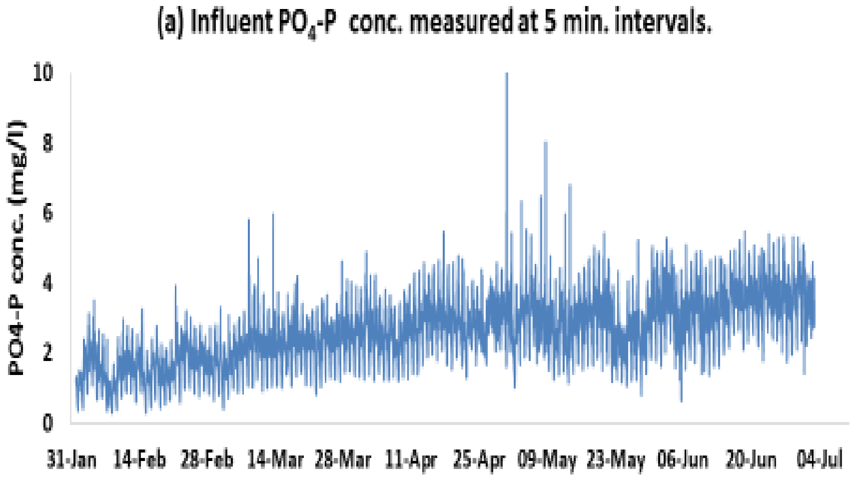

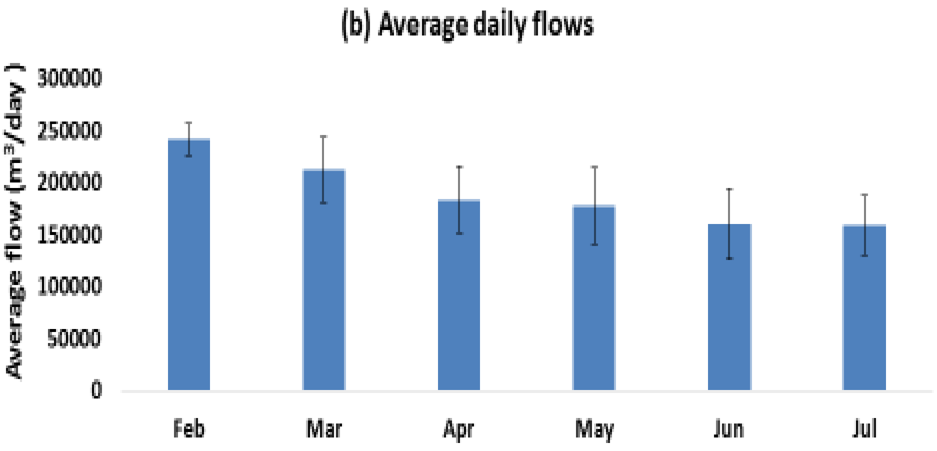

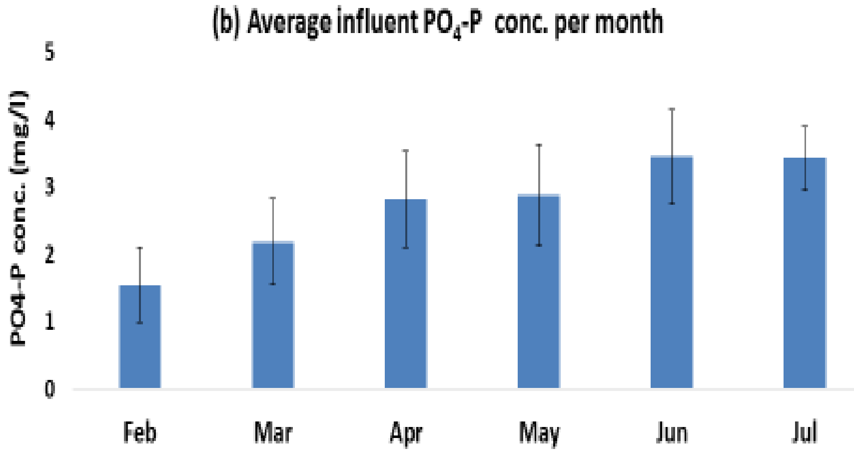

Diurnal dosing profiles for randomly selected days of the months under study.

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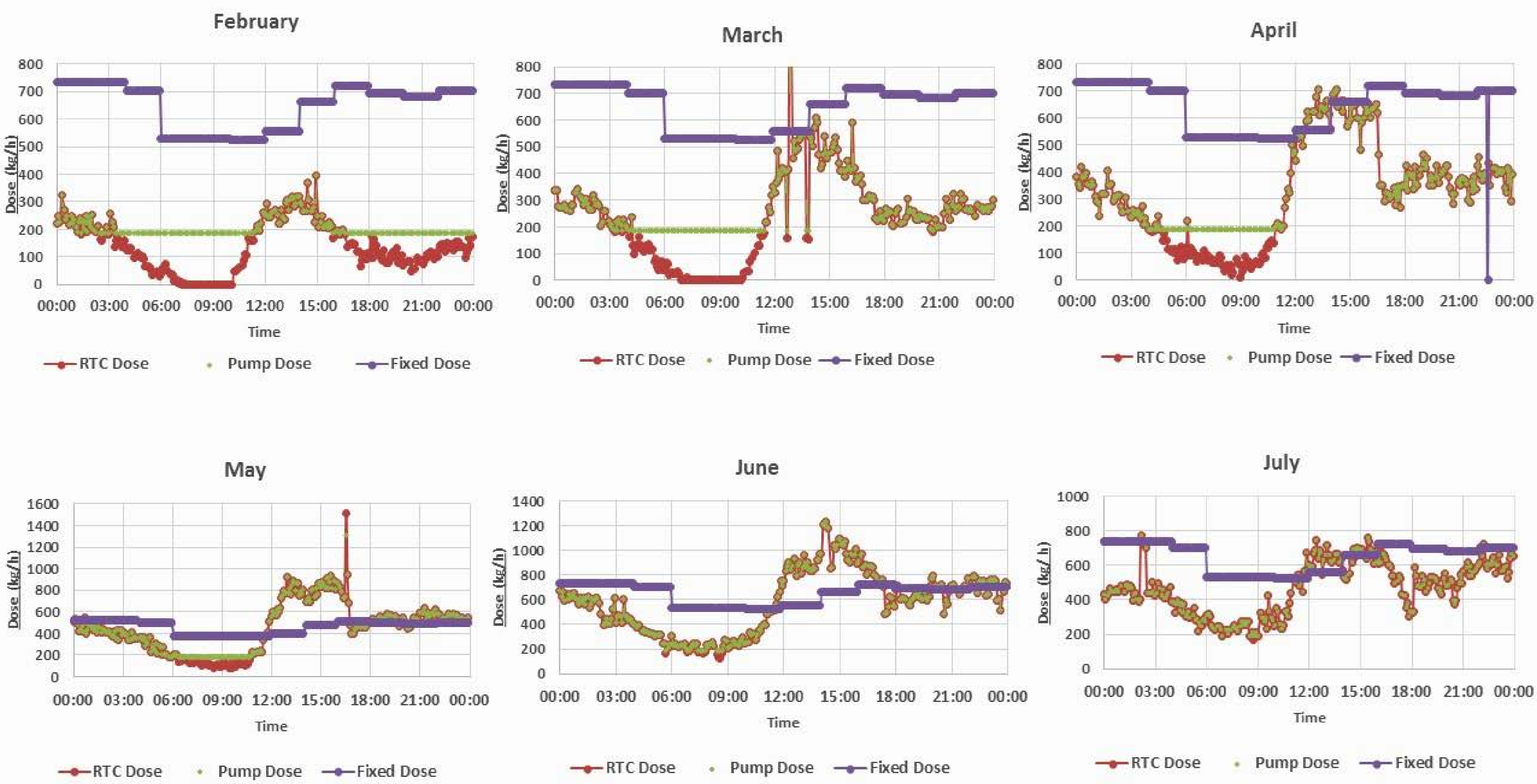

Costs and savings on chemicals for RTC compared to fixed dosing.

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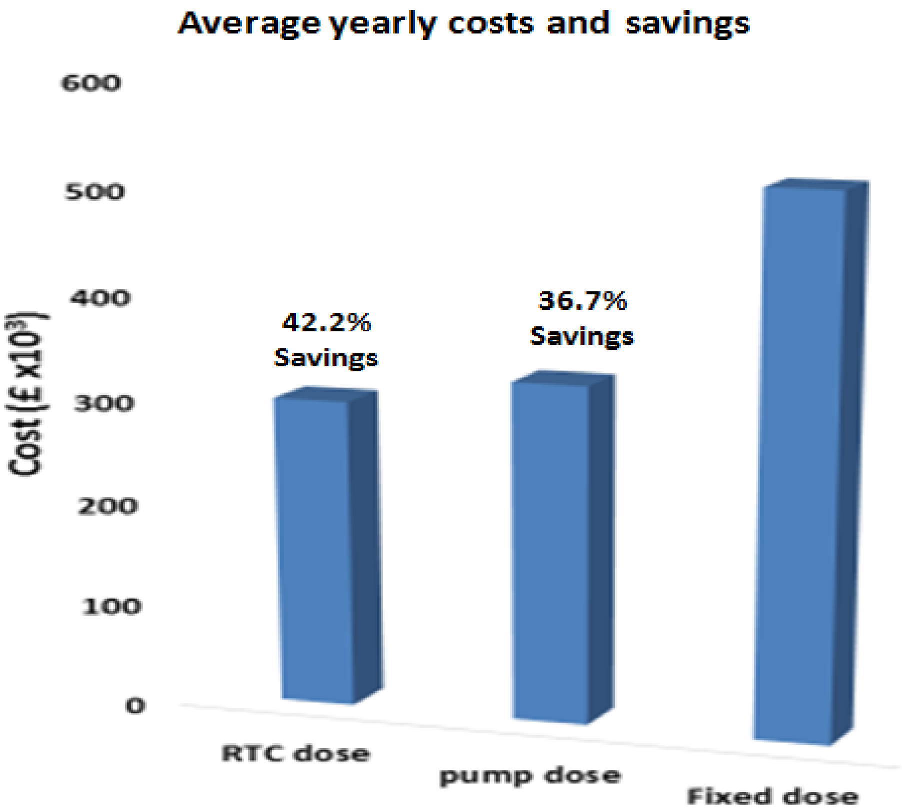
	Ave. Chemical consumption costs	
	£/month	£/yr.
RTC dose	25,029 ($US 38,794)	300,350 ($US 465,542)
Pump dose	27,420 ($US 42,501)	329,038 ($US 510,009)
Fixed dose	43,294 ($US 67,105)	519,525 ($US 805,263)



Payback Period

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Conclusions

- Online measurement and control guarantee improved treatment and reduced operational costs.
- Measurements are influenced by the accuracy and reliability of the method used.
- The use of online phosphorous sensors provide significant savings on chemical costs (42%) with short payback (<2 months) as demonstrated in the case study.

Thoughts/ Comments/ Questions?

Deon Anderson
MSc. Water & Wastewater Engineering