Full scale implementation of the External Nitrification BNR process at Daspoort WwTW

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Overview

- The City of Tshwane hosts the administrative seat of the South African government.
- Covers 6 368km^2, stretching 121 km east to west and 108 km north to south.
- Has 2,5 million residents, with 78% having access to waterborne sanitation.

Wastewater treatment: System description

- About 521 Ml/d of sewage is generated and treated.
- The sewage is collected and conveyed through 8 095 km of pipelines and 78 pump stations.
- The sewage is treated in 15 Wastewater Treatment Works (WwTW) distributed along the geography of the city with a combined design capacity of 600 Ml/d.
- Treated sewage effluents are discharged into receiving water bodies such as rivers and dams.
- 150 dry tons of sewage sludge is produced per day. A portion of the dewatered sludge is used as a base for the production of a commercial fertiliser.

Legislative framework

- Protection of water resources and water use is legislated through the National Water Act 36 of 1998 in SA.
- The national Department of Water & Sanitation (DWS) is the custodian of all water resources and regulates water uses.
- Discharge of sewage effluents into rivers and streams is considered a water use.
- All water users are required, by law, to apply for water use licences (WULs).
- DWS prescribes the quantity and quality of effluents, considerate of downstream water uses and maintenance of the reserve (basic human needs & ecological).

WUL discharge standards

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water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X313, Pretoria, 0001, Sedibeng Building, 185 Schoeman Street, Pretoria Tel: (012) 336-7500
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LICENCE IN TERMS OF CHAPTER 4 OF THE NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998) (THE ACT)

I, ***Thandeka Rose Mary Mbassa,*** in my capacity as Acting Director-General in the Department of Water Affairs and acting under authority of the powers delegated to me by the Minister of Water and Environmental Affairs, hereby authorise the following water uses in respect of this licence.

SIGNED: .....

DATE: 19/07/2011

LICENCE No. 27/2/2/A223/101/8
Ref. No. 16/2/7/A230/D7/X4

1. **Water User:** City of Tshwane
Postal Address of applicant: P.O. Box 1022
PRETORIA
0001

2. **Water Uses**

This licence is issued for the following water uses for the **Zeekoegat Wastewater Treatment Works** in terms of National Water Act, 1998 (Act 36 of 1998).

2.1 Section 21(e) of the Act: Engaging in a controlled activity, subject to the conditions set out in Appendices I and II.

2.2 Section 21(f) of the Act: Discharging waste or water containing waste into a water resource, subject to the conditions set out in Appendices I and III.

2.3 Section 21(g) of the Act: Disposing of waste in a manner which may detrimentally impact on a water resource, subject to the conditions as set out in Appendices I and IV.

3. **Properties on which the use will be exercised**

3.1 Section 21(e) of the Act: Portion 142 Zeekoegat 296 JR
3.2 Section 21(f) of the Act: Portion 142 Zeekoegat 296 JR
3.3 Section 21(g) of the Act: Portion 142 Zeekoegat 296 JR

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APPENDICES III

Section 21(f) of the Act: **Discharging waste or water containing waste into a water resource**

1. **QUANTITY OF EFFLUENT**

1.1 This licence authorises the discharge to the Roodeplaat Dam from the maturation dam of a maximum quantity of thirty one million cubic metres (31 000 000 m^3/a) of treated sewage effluent per annum, based on an average flow of eighty four thousand nine hundred and thirty two cubic metres (84 932 m^3/a) per day.

1.2 The quantity of effluent discharged to the Roodeplaat Dam on any given day shall not exceed two hundred and seventy two thousand cubic metres (272 000 m^3/a) per day.

1.3 The quantity of treated water containing waste authorised to be disposed of in terms of this licence may not be exceeded without prior authorization from the Department.

2. **QUALITY OF EFFLUENT**

2.1 The quality of the effluent discharged into the Roodeplaat Dam through the Maturation Dam may not exceed the following non-exceedance values or range:

Variable	Limit
pH	6.5 - 8.5
Electrical conductivity (EC)	80 mS/m
Total Suspended Solids (TSS)	10 mg/l
Chemical oxygen demand (COD)	50 mg/l
Free Residual Chlorine (as Cl)	0.2 µg/l
E. coli / Faecal Coliforms	0cfu/100ml
Ammonia (ionised and un-ionised) as Nitrogen (NH_3 as N)	1.0 mg/l
Nitrate/Nitrite as Nitrogen (NO_3/NO_2 as N)	6.0 mg/l
Ortho-Phosphate as Phosphorous (PO_4 as P) (2009 - 2011) after debottlenecking	0.9 mg/l
Ortho-Phosphate as Phosphorous (PO_4 as P) (2012 - 2015) after upgrade	0.5 mg/l
Ortho-Phosphate as Phosphorous (PO_4 as P) (2015 - 2018)	0.1 mg/l

Legislative framework (Continued)

- Sewage sludges are regulated through a set of documents titled " *Guidelines for the utilisation and disposal of sewage sludges*".
- The guidelines require that sludge be tested for microbiological (bacteria and Helminth ova), stability (vector attraction potential) and metal content.
- Processed sludge that is stable, free of microorganisms and acceptable metals concentration is classed as A1a and have unrestricted use.
- The guidelines further offers management options for lower sludge classes.

Traditional treatment technologies

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Liquid processes

- Biological nutrient removal activated sludge (BNRAS)
- Trickling filters (TF)
- Extended aeration

Solids processes

- Anaerobic digestion (AD)
- Belt filter presses (BFPs)
- Solar drying and processing for fertiliser production

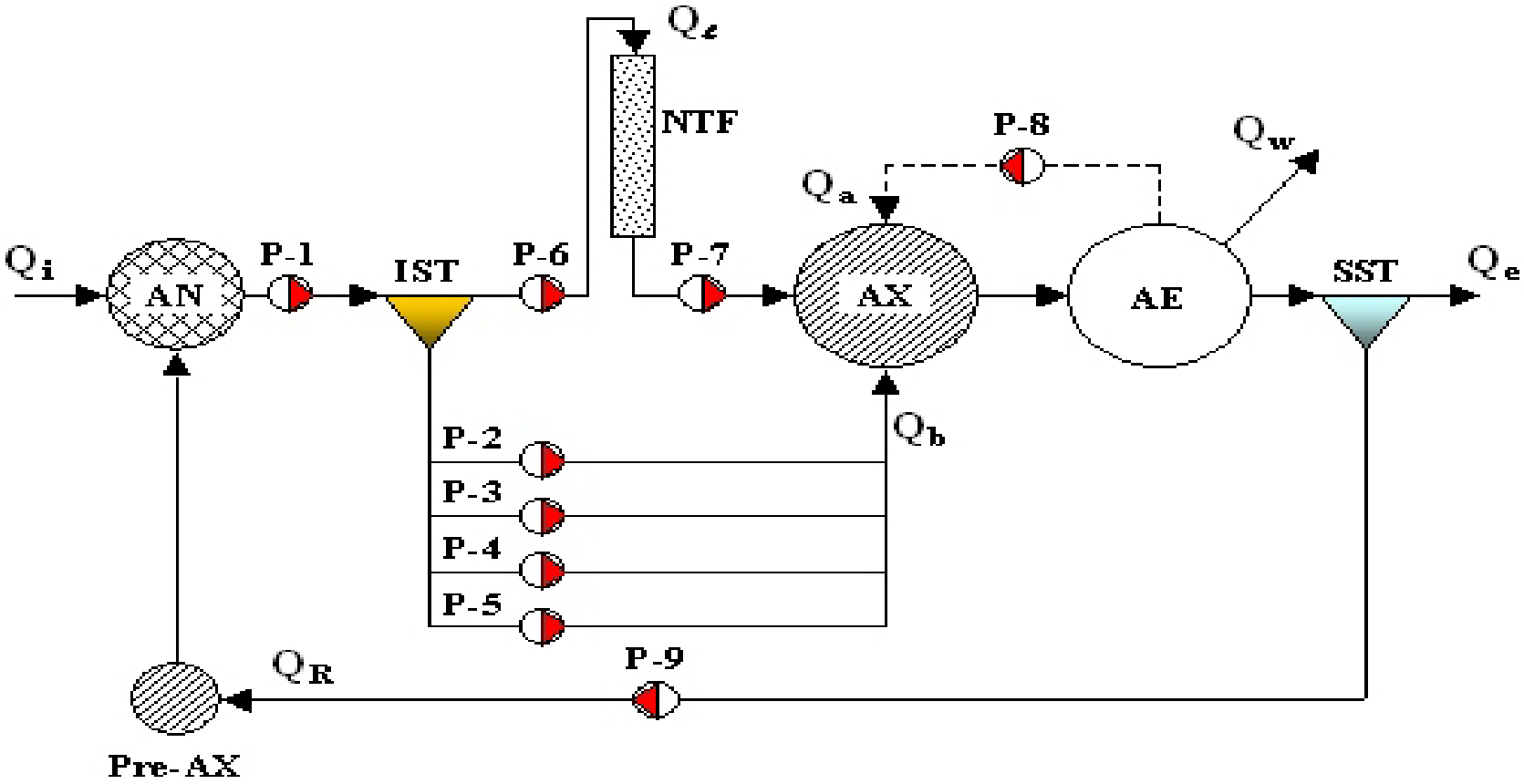
Pursuit for improved discharges…

- Conventional activated sludge processes struggle to meet stringent DWS standards imposes, e.g. 0.1 mg/l P
- Partnerships are sought with academia and research institutions to improve treatment processes.
- One such partnership between CoT, Water Research Commission & University of Cape Town produced the External Nitrification Biological Nutrient Removal Activated Sludge process.
- The project was implemented at the Daspoort WwTW.

Modification to external nitrification

- 1 of 3 BNR modules (reactor 9) was modified for ENBNRAS
- The aerobic zone was reduced to extend the anoxic zone
- 4 Dortmund type PSTs were modified to serve as internal settling tank
- Existing high rate trickling filters were used for nitrification in a lead and follow configuration
- Additional pumps and pipework was installed to convey mixed liquor from and to different points.

Process configuration



Note: The ◐ symbol denotes a pump.

Design parameters

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Average design characristics of settled sewage influent at Daspoort WwTW for External Nitrification			
Settled sewage influent parameter	Symbol	Value	Unit
Influent flowrate	Q_i	14	Ml/d
COD concentration	S_{ti}	320	mgCOD/l
Unbiodegradable particulate fraction	f_{up}	0.04*	COD/COD
Unbiodegradable soluble fraction	f_{us}	0.10*	COD/COD
TKN concentration	N_{ti}	35.8	mgN/l
Ammonia concentration	N_{ai}	19.5	mgN/l
Nitrate concentration	NO_3	0.0	mgN/l
Ortho-P concentration	PO_4	4.5	mgP/l
Total-P concentration	P_{ti}	5.8	mgP/l

* indicates assumed value

Advantages

- South Africa has invested a lot of capital in the construction of trickling filters (TFs).
- The TFs offer no operational flexibility and cannot meet progressively stringent discharge standards.
- The TFs are however good for nitrification with almost zero energy cost.
- BNRAS offers good phosphate and nitrate removal
- Solution: Combine the best of the two technologies

Advantages (Cont...)

- Slow growing nitrifying bacteria are removed from the BNRAS system to TFs (suspended to fixed growth)
- This prevents washout during process upsets and provides nitrification at reduced energy costs.
- Advantages include reduced bioreactor volumes, secondary settling and oxygen demand.
- The advantages translate to lower capital costs in treatment works with pre-existing TF plants.

Results

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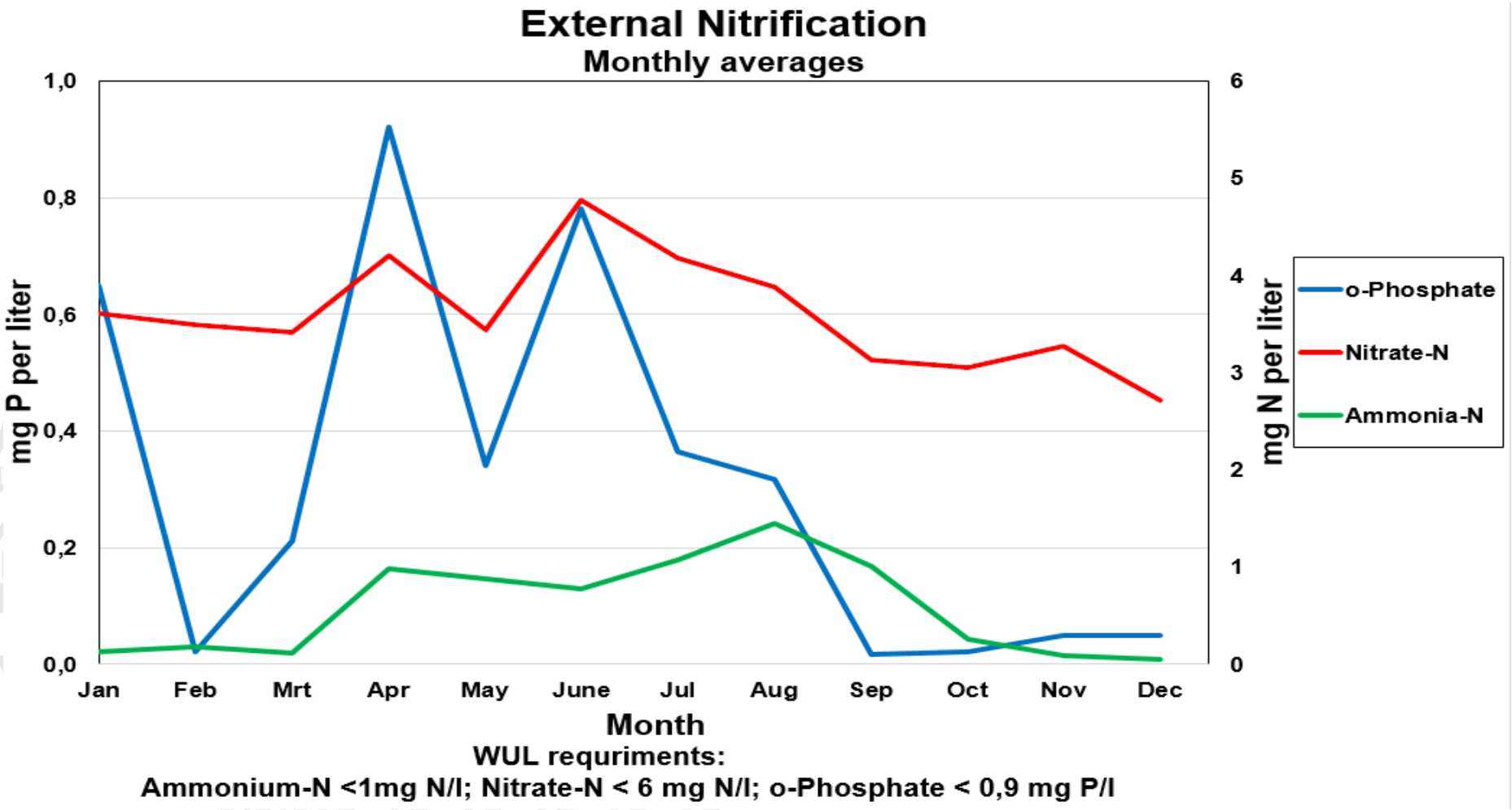

WUL requriments:

Ammonium-N <1mg N/l; Nitrate-N < 6 mg N/l; o-Phosphate < 0,9 mg P/l

Performance comparison

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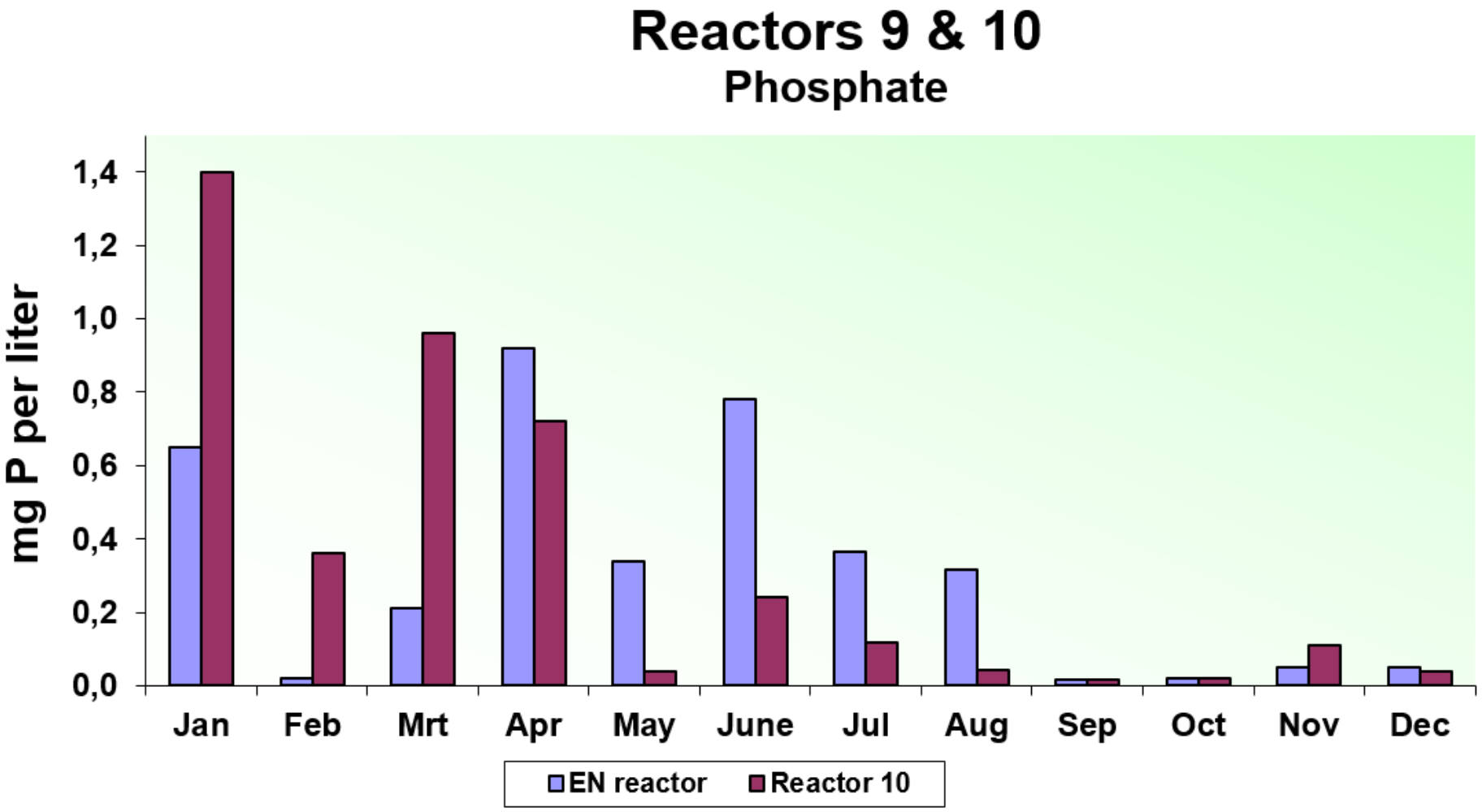

Performance comparison

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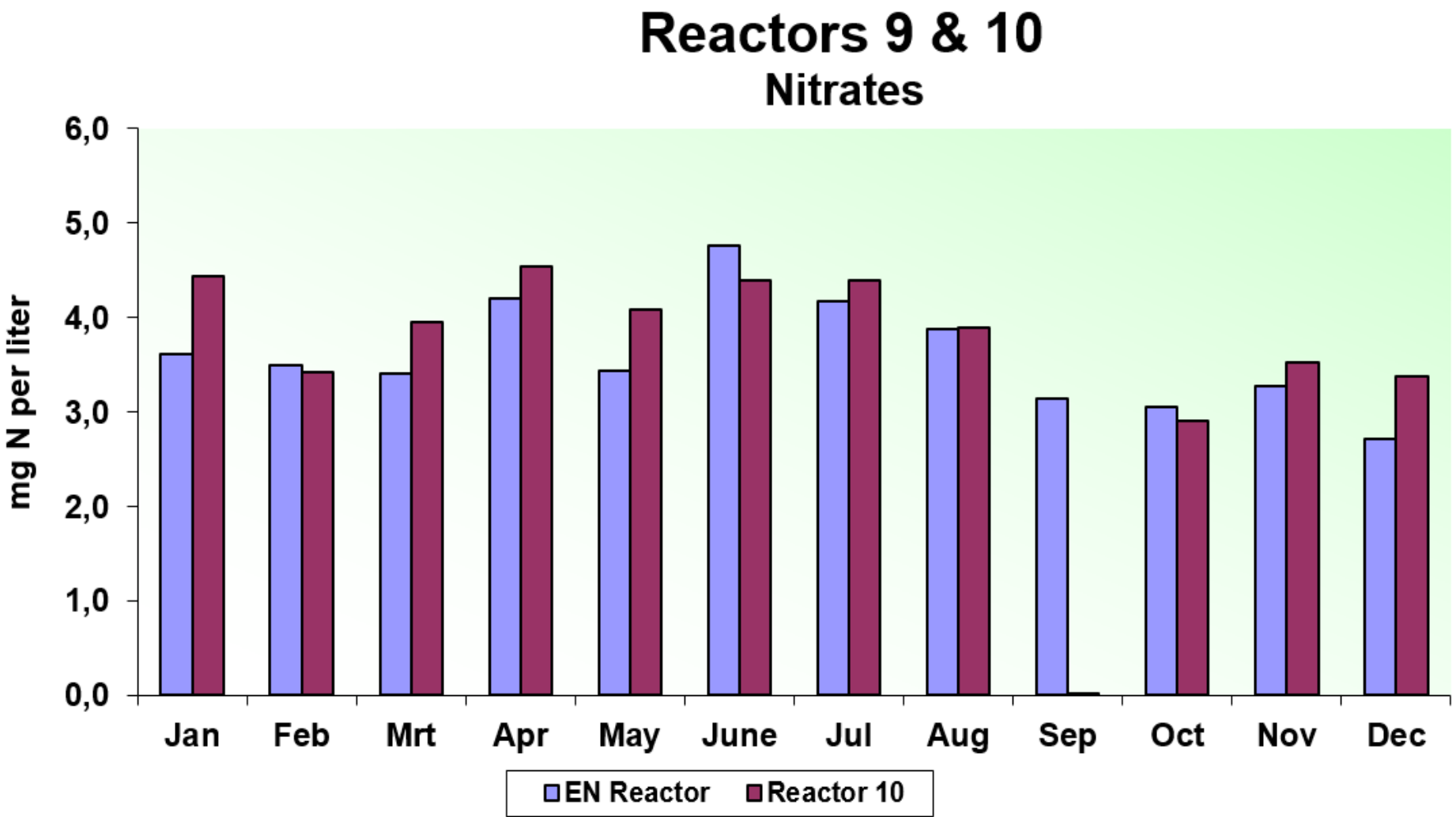

Performance comparison

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