Le prix Otto Jaag pour la protection des eaux 2024 revient à Valentin Faust

18 novembre 2024 | Claudia Carle
Catégories: Eaux usées | Organisation et personnel

Lors de la Journée de l'EPF du 16 novembre, la thèse de Valentin Faust, ingénieur de l'environnement, a été récompensée du prix Otto Jaag pour la protection des eaux. Celle-ci fournit d'importantes connaissances pour la fabrication d'engrais à partir d'urine humaine.

L'EPF Zurich décerne le prix Otto Jaag pour la protection des eaux à des mémoires de master et de doctorat remarquables dans le domaine de la protection des eaux et des sciences aquatiques. Cette année, cette distinction a été décernée à Valentin Faust dans le cadre de la Journée de l'EPF du 16 novembre, pour sa thèse intitulée «Effects of pH on urine nitrification: from microbial selection to process performance».

Son travail faisait partie du programme de recherche spatiale MELiSSA de l'Agence spatiale européenne (ESA). MELiSSA est l'acronyme de «Micro Ecological Life Support System Alternative» et a pour objectif de développer des systèmes permettant à terme d'envoyer des missions spatiales habitées, par exemple sur Mars. À cette fin, il est essentiel de disposer de systèmes régénérateurs, qui produisent en circuits fermés alimentation, eau et oxygène à partir des déchets engendrés. L'engrais pour la production d'aliments serait produit à partir de l'urine.

Augmenter la stabilité des processus pour une utilisation dans l'espace

L'Eawag travaille depuis longtemps sur les processus nécessaires à la récupération de ressources dans les eaux usées ainsi que sur des systèmes sanitaires autarciques pour les lieux sans canalisations ni raccordement à l'eau. Pour pouvoir être utilisé dans l'espace, ce processus à plusieurs étapes de récupération de l'azote, du phosphore et d'autres nutriments dans l'urine doit être parfaitement fiable et fonctionner sans perturbations. L’objectif de Valentin Faust, doctorant au département Technologie des procédés de l’Eawag, consistait par conséquent à augmenter la stabilité du processus de traitement de l’urine tout en réduisant l’empreinte carbone du procédé. Dans ce but, il a notamment étudié en détail l’étape de nitrification, durant laquelle des bactéries transforment l’ammonium contenu dans l’urine en nitrate. Cette réaction est très sensible aux changements de la valeur du pH. Valentin Faust a étudié l’impact de cette dernière sur la composition des microorganismes ainsi que sur l’apparition de produits de réaction indésirables, tels que le nitrite ou le gaz hilarant, un polluant climatique.

À cet effet, il a travaillé notamment avec des réacteurs de nitrification en laboratoire et dans un environnement pilote, et modélisé le processus en question pour prédire les conditions dans lesquelles celui-ci s’arrête, et déterminer les stratégies d’exploitation qui permettent une nitrification stable aussi écologique que possible.

Des conclusions précieuses aussi pour une utilisation terrestre

«Les résultats de Valentin Faust fournissent d’importantes connaissances pour le fonctionnement des réacteurs de nitrification destinés à fabriquer de l’engrais à partir d’urine humaine», explique Kai Udert, directeur de thèse du doctorant et responsable de groupe au département Technologie des processus de l’Eawag. «C’est extrêmement précieux pour le développement ultérieur d’une gestion de l’eau axée sur la récupération des ressources en zones urbaines, avec pour objectif de fermer les cycles de nutriments et de protéger les eaux.»

Valentin Faust est ravi de cette distinction. «J’ai eu beaucoup de plaisir à travailler au sein d’une équipe internationale sur les défis posés par un système circulaire, qu’il soit employé sur terre ou dans l’espace». Il ignore encore ce qu’il fera de l’argent gagné avec ce prix. «En tout cas, je n’achèterai pas un vol pour la lune». Après un bref postdoc à l’Eawag, Valentin Faust travaille à présent comme responsable de projet à la Haute école spécialisée de Suisse orientale (OST) dans le groupe spécialisé de Chimie appliquée aux eaux usées, à l’eau et aux odeurs.

Photo de couverture: Le recteur de l’EPF, Günther Dissertori, remet à Valentin Faust le prix Otto Jaag pour la protection des eaux (Photo: EPF, Alessandro Della Bella).

Publications originales

.extbase-debugger-tree{position:relative}.extbase-debugger-tree input{position:absolute !important;float: none !important;top:0;left:0;height:14px;width:14px;margin:0 !important;cursor:pointer;opacity:0;z-index:2}.extbase-debugger-tree input~.extbase-debug-content{display:none}.extbase-debugger-tree .extbase-debug-header:before{position:relative;top:3px;content:"";padding:0;line-height:10px;height:12px;width:12px;text-align:center;margin:0 3px 0 0;background-image:url(data:image/svg+xml;base64,PD94bWwgdmVyc2lvbj0iMS4wIiBlbmNvZGluZz0idXRmLTgiPz48c3ZnIHZlcnNpb249IjEuMSIgaWQ9IkViZW5lXzEiIHhtbG5zPSJodHRwOi8vd3d3LnczLm9yZy8yMDAwL3N2ZyIgeG1sbnM6eGxpbms9Imh0dHA6Ly93d3cudzMub3JnLzE5OTkveGxpbmsiIHg9IjBweCIgeT0iMHB4IiB2aWV3Qm94PSIwIDAgMTIgMTIiIHN0eWxlPSJlbmFibGUtYmFja2dyb3VuZDpuZXcgMCAwIDEyIDEyOyIgeG1sOnNwYWNlPSJwcmVzZXJ2ZSI+PHN0eWxlIHR5cGU9InRleHQvY3NzIj4uc3Qwe2ZpbGw6Izg4ODg4ODt9PC9zdHlsZT48cGF0aCBpZD0iQm9yZGVyIiBjbGFzcz0ic3QwIiBkPSJNMTEsMTFIMFYwaDExVjExeiBNMTAsMUgxdjloOVYxeiIvPjxnIGlkPSJJbm5lciI+PHJlY3QgeD0iMiIgeT0iNSIgY2xhc3M9InN0MCIgd2lkdGg9IjciIGhlaWdodD0iMSIvPjxyZWN0IHg9IjUiIHk9IjIiIGNsYXNzPSJzdDAiIHdpZHRoPSIxIiBoZWlnaHQ9IjciLz48L2c+PC9zdmc+);display:inline-block}.extbase-debugger-tree

input:checked~.extbase-debug-content{display:inline}.extbase-debugger-tree input:checked~.extbase-debug-header:before{background-image:url(data:image/svg+xml;base64,PD94bWwgdmVyc2lvbj0iMS4wIiBlbmNvZGluZz0idXRmLTgiPz48c3ZnIHZlcnNpb249IjEuMSIgaWQ9IkViZW5lXzEiIHhtbG5zPSJodHRwOi8vd3d3LnczLm9yZy8yMDAwL3N2ZyIgeG1sbnM6eGxpbms9Imh0dHA6Ly93d3cudzMub3JnLzE5OTkveGxpbmsiIHg9IjBweCIgeT0iMHB4IiB2aWV3Qm94PSIwIDAgMTIgMTIiIHN0eWxlPSJlbmFibGUtYmFja2dyb3VuZDpuZXcgMCAwIDEyIDEyOyIgeG1sOnNwYWNlPSJwcmVzZXJ2ZSI+PHN0eWxlIHR5cGU9InRleHQvY3NzIj4uc3Qwe2ZpbGw6Izg4ODg4ODt9PC9zdHlsZT48cGF0aCBpZD0iQm9yZGVyIiBjbGFzcz0ic3QwIiBkPSJNMTEsMTFIMFYwaDExVjExeiBNMTAsMUgxdjloOVYxeiIvPjxnIGlkPSJJbm5lciI+PHJlY3QgeD0iMiIgeT0iNSIgY2xhc3M9InN0MCIgd2lkdGg9IjciIGhlaWdodD0iMSIvPjwvZz48L3N2Zz4=)}.extbase-debugger{display:block;text-align:left;background:#2a2a2a;border:1px solid #2a2a2a;box-shadow:0 3px 0 rgba(0,0,0,.5);color:#000;margin:20px;overflow:hidden;border-radius:4px}.extbase-debugger-floating{position:relative;z-index:999}.extbase-debugger-top{background:#444;font-size:12px;font-family:monospace;color:#f1f1f1;padding:6px 15px}.extbase-debugger-center{padding:0 15px;margin:15px 0;background-image:repeating-linear-gradient(to bottom,transparent 0,transparent 20px,#252525 20px,#252525 40px)}.extbase-debugger-center,.extbase-debugger-center .extbase-debug-string,.extbase-debugger-center a,.extbase-debugger-center p,.extbase-debugger-center pre,.extbase-debugger-center strong{font-size:12px;font-weight:400;font-family:monospace;line-height:20px;color:#f1f1f1}.extbase-debugger-center pre{background-color:transparent;margin:0;padding:0;border:0;word-wrap:break-word;color:#999}.extbase-debugger-center .extbase-debug-string{color:#ce9178;white-space:normal}.extbase-debugger-center .extbase-debug-type{color:#569CD6;padding-right:4px}.extbase-debugger-center .extbase-debug-unregistered{background-color:#dce1e8}.extbase-debugger-center .extbase-debug-filtered,.extbase-debugger-center .extbase-debug-proxy,.extbase-debugger-center .extbase-debug-ptype,.extbase-debugger-center .extbase-debug-visibility,.extbase-debugger-center .extbase-debug-scope{color:#fff;font-size:10px;line-height:12px;padding:2px 4px;margin-right:2px;position:relative;top:-1px}.extbase-debugger-center .extbase-debug-scope{background-color:#497AA2}.extbase-debugger-center .extbase-debug-ptype{background-color:#698747}.extbase-debugger-center .extbase-debug-visibility{background-color:#698747}.extbase-debugger-center .extbase-debug-dirty{background-color:#FFFFB6}.extbase-debugger-center .extbase-debug-filtered{background-color:#4F4F4F}.extbase-debugger-center .extbase-debug-seeabove{text-decoration:none;font-style:italic}.extbase-debugger-center .extbase-debug-property{color:#f1f1f1}.extbase-debugger-center .extbase-debug-closure{color:#9BA223;}Extbase Variable Dumparray(3 items) publications => '25984,25835,32033,32321' (23 chars) libraryUrl => '' (0 chars) layout => '0' (1 chars) Extbase Variable Dumparray(4 items) 0 => Snowflake\Publications\Domain\Model\Publicationprototypepersistent entity (uid=25984, pid=124) originalId => protected25984 (integer) authors => protected'Faust, V.; van Alen, T. A.; Op den Camp, H. J.
;M.; Vlaeminck, S. E.; Ganigué, R.; Boon, N.; Udert,&nb
sp;K. M.' (165 chars) title => protected'Ammonia oxidation by novel "Candidatus Nitrosacidococcus urinae" is
sensitive to process disturbances at low pH and to iron limitation at neutr
al pH' (157 chars) journal => protected'Water Research X' (16 chars) year => protected2022 (integer) volume => protected17 (integer) issue => protected'' (0 chars) startpage => protected'100157 (11 pp.)' (15 chars) otherpage => protected'' (0 chars)

categories => protected'nitrification; acidophilic AOB; source separation; chemical nitrite oxidatio
n; human urine; life support system' (111 chars) description => protected'Acid-tolerant ammonia-oxidizing bacteria (AOB) can open the door to new appl
ications, such as partial nitritation at low pH. However, they can also be p
roblematic because chemical nitrite oxidation occurs at low pH, leading to t
he release of harmful nitrogen oxide gases. In this publication, the role of
 acid-tolerant AOB in urine treatment was explored. On the one hand, the tec
hnical feasibility of ammonia oxidation under acidic conditions for source-s
eparated urine with total nitrogen concentrations up to 3.5 g-N L<sup>-1</
sup> was investigated. On the other hand, the abundance and growth of acid-t
olerant AOB at more neutral pH was explored. Under acidic conditions (pH of
 5), ammonia oxidation rates of 500 mg-N L⁻¹ d⁻¹ an
d 10 g-N g-VSS⁻¹ d⁻¹ were observed, despite high con
centrations of 15 mg-N L⁻¹ of the AOB-inhibiting compound nitro
us acid and low concentration of 0.04 mg-N L⁻¹ of the substrate
 ammonia. However, ammonia oxidation under acidic conditions was very sensit
ive to process disturbances. Even short periods of less than 12 h without ox
ygen or without influent resulted in a complete cessation of ammonia oxidati
on with a recovery time of up to two months, which is a problem for low main
tenance applications such as decentralized treatment. Furthermore, undesirab
le nitrogen losses of about 10% were observed. Under acidic conditions, a no
vel AOB strain was enriched with a relative abundance of up to 80%, for whic
h the name “Candidatus (Ca.) Nitrosacidococcus urinae” is propo
sed. While Nitrosacidococcus members were present only to a small e
xtent (0.004%) in urine nitrification reactors operated at pH values between
 5.8 and 7, acid-tolerant AOB were always enriched during long periods witho
ut influent, resulting in an uncontrolled drop in pH to as low as 2.5. Long-
term experiments at different pH values showed that the activity of “C
a. Nitrosacidococcu...' (2324 chars) serialnumber => protected'2589-9147' (9 chars) doi => protected'10.1016/j.wroa.2022.100157' (26 chars) uid => protected25984 (integer) _localizedUid => protected25984 (integer)modified _languageUid => protectedNULL _versionedUid => protected25984 (integer)modified pid => protected124 (integer) 1 => Snowflake\Publications\Domain\Model\Publicationprototypepersistent entity (uid=25835, pid=124) originalId => protected25835 (integer) authors => protected'Faust, V.; Gruber, W.; Ganigué, R.; Vlaeminck, S.
E.; Udert, K. M.' (102 chars) title => protected'Nitrous oxide emissions and carbon footprint of decentralized urine fertiliz
er production by nitrification and distillation' (123 chars) journal => protected'ACS ES&T Engineering' (20 chars) year => protected2022 (integer) volume => protected2 (integer) issue => protected'9' (1 chars) startpage => protected'1745' (4 chars) otherpage => protected'1755' (4 chars) categories => protected'greenhouse gas emissions; resource recovery; MELiSSA; nitrite sensor; digest
er supernatant' (90 chars) description => protected'Combining partial nitrification, granular activated carbon (GAC) filtration,
 and distillation is a well-studied approach to convert urine into a fertili
zer. To evaluate the environmental sustainability of a technology, the opera
tional carbon footprint and therefore nitrous oxide (N₂O) emissio

ns should be known, but N₂O emissions from urine nitrification ha
ve not been assessed yet. Therefore, N₂O emissions of a decentral
ized urine nitrification reactor were monitored for 1 month. During nitrific
ation, 0.4-1.2% of the total nitrogen load was emitted as N₂O-N w
ith an average N₂O emission factor (EF_{N₂O})
of 0.7%. Additional N₂O was produced during anoxic storage betwee
n nitrification and GAC filtration with an estimated EF<sub>N₂O</
sub> of 0.8%, resulting in an EF_{N₂O} of 1.5% for the tr
eatment chain. N₂O emissions during nitrification can be mitigate
d by 60% by avoiding low dissolved oxygen or anoxic conditions and nitrite c
oncentrations above 5 mg-N L⁻¹. Minimizing the hydraulic retentio
n time between nitrification and GAC filtration can reduce N₂O fo
rmation during intermediate storage by 100%. Overall, the N₂O emi
ssions accounted for 45% of the operational carbon footprint of 14 kg-CO<sub
>2,equiv</sub> kg-N⁻¹ for urine fertilizer production. Using elec
tricity from renewable sources and applying the proposed N₂O miti
gation strategies could potentially lower the carbon footprint by 85%.' (1590 chars)
serialnumber => protected'' (0 chars) doi => protected'10.1021/acsestengg.2c00082' (26
chars) uid => protected25835 (integer) _localizedUid => protected25835 (integer)modified
_languageUid => protectedNULL _versionedUid => protected25835 (integer)modified pid =>
protected124 (integer) 2 =>
Snowflake\Publications\Domain\Model\Publicationprototypepersistent entity (uid=32033,
pid=124) originalId => protected32033 (integer) authors => protected'Faust, V.;
Boon, N.; Ganigué, R.; Vlaeminck, S. E.
; Udert, K. M.' (100 chars) title => protected'Optimizing control strategies for
urine nitrification: narrow pH control ban
d enhances process stability and reduces nitrous oxide emissions' (140 chars) journal
=> protected'Frontiers in Environmental Science' (34 chars) year => protected2023 (integer)
volume => protected11 (integer) issue => protected'' (0 chars) startpage =>
protected'1275152 (14 pp.)' (16 chars) otherpage => protected'' (0 chars) categories =>
protected'resource recovery; decentralized treatment; microbial diversity; source sepa
ration; robustness; MELiSSA; process stability' (122 chars) description =>
protected'Nitrification is well-suited for urine stabilization. No base dosage is requ
ired if the pH is controlled within an appropriate operating range by urine
feeding, producing an ammonium-nitrate fertilizer. However, the process is h
ighly dependent on the selected pH set-points and is susceptible to process
failures such as nitrite accumulation or the growth of acid-tolerant ammonia
-oxidizing bacteria. To address the need for a robust and reliable process i
n decentralized applications, two different strategies were tested: operatin
g a two-position pH controller (inflow on/off) with a narrow pH control band
at 6.20/6.25 (?pH = 0.05, narrow-pH) vs. a wider pH control band at 6.00/
6.50 (?pH = 0.50, wide-pH). These variations in pH also cause variations i
n the chemical speciation of ammonia and nitrite and, as shown, the microbia
l production of nitrite. It was hypothesized that the higher fluctuations wo
uld result in greater microbial diversity and, thus, a more robust process.
The diversity of nitrifiers was higher in the wide-pH reactor, while the div
ersity of the entire microbiome was similar in both systems. However, the wi
de-pH reactor was more susceptible to tested process disturbances caused by

Überlandstrasse 133
CH-8600 Dübendorf
T +41 58 765 55 11
F +41 58 765 50 28
info@eawag.ch
www.eawag.ch

increasing pH or temperature, decreasing dissolved oxygen, or an influent st
op. In addition, with an emission factor of 0.47%, the nitrous oxide (N<sub>
2</sub>O) emissions from the wide-pH reactor were twice as high as the N<sub
>2</sub>O emissions from the narrow-pH reactor, most likely due to the nitri
te fluctuations. Based on these results, a narrow control band is recommende
d for pH control in urine nitrification.' (1636 chars) serialnumber => protected'' (0 chars)
doi => protected'10.3389/fenvs.2023.1275152' (26 chars) uid => protected32033 (integer)
_localizedUid => protected32033 (integer)modified _languageUid => protectedNULL
_versionedUid => protected32033 (integer)modified pid => protected124 (integer) 3 =>
Snowflake\Publications\Domain\Model\Publicationprototypepersistent entity (uid=32321,
pid=124) originalId => protected32321 (integer) authors => protected'Faust, V.;
Vlaeminck, S. E.; Ganigué, R.; Udert, K
. M.' (85 chars) title => protected'Influence of pH on urine nitrification: community
shifts of ammonia-oxidizin
g bacteria and inhibition of nitrite-oxidizing bacteria' (131 chars) journal =>
protected'ACS ES&T Engineering' (20 chars) year => protected2024 (integer) volume =>
protected4 (integer) issue => protected'2' (1 chars) startpage => protected'342' (3 chars)
otherpage => protected'353' (3 chars) categories => protected'source separation; resource
recovery; nutrient recovery; decentralized treat
ment; fertilizer production' (103 chars) description => protected'Urine nitrification is pH-
sensitive due to limited alkalinity and high resid
ual ammonium concentrations. This study aimed to investigate how the pH affe
cts nitrogen conversion and the microbial community of urine nitrification w
ith a pH-based feeding strategy. First, kinetic parameters for NH<sub>3</sub
>, HNO₂, and NO₂⁻ limitation and inhibition
were determined for nitrifiers from a urine nitrification reactor. The turn
ing point for ammonia-oxidizing bacteria (AOB), i.e., the substrate concentr
ation at which a further increase would lead to a decrease in activity due t
o inhibitory effects, was at an NH₃ concentration of 12 mg-N L<su
p>-1</sup>, which was reached only at pH values above 7. The total nitrite t
urning point for nitrite-oxidizing bacteria (NOB) was pH-dependent, e.g., 18
mg-N L⁻¹ at pH 6.3. Second, four years of data from two 120 L re
actors were analyzed, showing that stable nitrification with low nitrite was
most likely between pH 5.8 and 6.7. And third, six 12 L urine nitrification
reactors were operated at total nitrogen concentrations of 1300 and 3600 mg
-N L⁻¹ and pH values between 2.5 and 8.5. At pH 6, the AOB Nitros
omonas europaea was found, and the NOB belonged to the genus Nitrobacter. At
pH 7, nitrite accumulated, and Nitrosomonas halophila was the dominant AOB.
NOB were inhibited by HNO₂ accumulation. At pH 8.5, the AOB Nitr
osomonas stercoris became dominant, and NH₃ inhibited NOB. Withou
t influent, the pH dropped to 2.5 due to the growth of the acid-tolerant AOB
“Candidatus Nitrosacidococcus urinae”. In conclusion, pH is a decisive
process control parameter for urine nitrification by influencing the selecti
on and kinetics of nitrifiers.' (1778 chars) serialnumber => protected'' (0 chars) doi =>
protected'10.1021/acsestengg.3c00320' (26 chars) uid => protected32321 (integer)
_localizedUid => protected32321 (integer)modified _languageUid => protectedNULL
_versionedUid => protected32321 (integer)modified pid => protected124 (integer) Faust, V.;
van Alen, T. A.; Op den Camp, H. J. M.; Vlaeminck, S. E.; Ganigué, R.; Boon, N.; Udert, K. M.

(2022) Ammonia oxidation by novel "*Candidatus* Nitrosacidococcus urinae" is sensitive to process disturbances at low pH and to iron limitation at neutral pH, *Water Research X*, 17, 100157 (11 pp.), doi:10.1016/j.wroa.2022.100157, Institutional Repository

Faust, V.; Gruber, W.; Ganigué, R.; Vlaeminck, S. E.; Udert, K. M. (2022) Nitrous oxide emissions and carbon footprint of decentralized urine fertilizer production by nitrification and distillation, *ACS ES&T Engineering*, 2(9), 1745-1755, doi:10.1021/acsestengg.2c00082, Institutional Repository

Faust, V.; Boon, N.; Ganigué, R.; Vlaeminck, S. E.; Udert, K. M. (2023) Optimizing control strategies for urine nitrification: narrow pH control band enhances process stability and reduces nitrous oxide emissions, *Frontiers in Environmental Science*, 11, 1275152 (14 pp.), doi:10.3389/fenvs.2023.1275152, Institutional Repository

Faust, V.; Vlaeminck, S. E.; Ganigué, R.; Udert, K. M. (2024) Influence of pH on urine nitrification: community shifts of ammonia-oxidizing bacteria and inhibition of nitrite-oxidizing bacteria, *ACS ES&T Engineering*, 4(2), 342-353, doi:10.1021/acsestengg.3c00320, Institutional Repository

Links

Prix Otto Jaag pour la protection des eaux

Page du projet “Melissa Space Research Program”

Melissa Foundation

Contact

Kai Udert

Tel. +41 58 765 5360

kai.udert@eawag.ch

Claudia Carle

Rédactrice scientifique

Tel. +41 58 765 5946

claudia.carle@eawag.ch

https://www.eawag.ch/fr/portail/dinfo/actualites/news-archives/detail-de-larchive/le-prix-otto-jaag-pour-la-protection-des-eaux-2024-revient-a-valentin-faust