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► **To cite this version:**

S Guillaume, N Forquet, J Pueyo-Ros, J Comas. Ontology: a tool to ease communication and reveal hidden knowledge -Application to nature-based solutions. 17th International Conference on Wetland Systems for Water Pollution Control, INRAE; RESEED; INSA/Lyon (National Institute of Applied Sciences); INSA/Lyon (Laboratory Waste Water, Environment, Pollution), Nov 2022, Lyon, France. <hal-04922961>

HAL Id: hal-04922961

<https://hal.inrae.fr/hal-04922961v1>

Submitted on 31 Jan 2025

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HAL Authorization

17th International Conference on Wetland Systems for Water Pollution Control



Conference Proceedings

6 – 10 November 2022
Lyon, France

ORGANIZED BY:



IN PARTNERSHIP WITH:



Ontology: a tool to ease communication and reveal hidden knowledge - Application to nature-based solutions

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Abstract

The implementation of Nature-based Solutions (NBS) in cities has shifted to an integrated approach paradigm, raising the need for a shared, explicit and formal representation of knowledge on NBS in urban water management. A solution is building an ontology: it is a representation that merges data and expert knowledge, prevents miscommunication, handles heterogeneous data types and formats, and can draw inferences. The ontology we present here was focused on describing a water treatment chain (core ontology), classifying NBS (notably Treatment Wetlands (TW)) and treatment mechanisms. Its construction has mobilized expert knowledge, existing ontologies and explicitation of relations between concepts, sometimes from different knowledge domains: technical, geographical, socio-environmental. The ontology is not only for description of NBS in urban water management, but also for better future database structuration and modelling purposes (for predictions in a decision-making support tool). The ontology will improve from iterative expert feedback.

Keywords

Inferences; knowledge management/modelling; nature-based solutions; ontology; treatment wetlands; urban water management

INTRODUCTION

Urban water management has shifted from treatment to water reuse and byproducts valorization paradigm, for enhancement of cities resiliency through circularity. Nature-based Solutions (NBS), particularly Treatment Wetlands (TW) (Masi et al., 2018), participate in a more decentralized, flexible and integrated urban water management, answering technical, economic and socio-environmental issues (Langergraber et al., 2021). Projects of implementation of NBS in cities now follow an integrated approach and require collaboration between agents of different expertises: technical, geographical, socio-environmental, regulations.. To this diversity is added the diversity of forms of knowledge: expert knowledge, classifications, thesaurus, glossaries, collections of concepts, expert rules, (or even rawer forms like implicit knowledge, data), and the diversity of data types and formats.

This diversity can be a hurdle to exchanges, to assessing and comparing NBS, and to knowledge mobilization for integrated modelling (Fletcher et al., 2015, Castellar et al., 2021). Neither consensual terminology nor homogeneous data format have been defined while the number of innovations and quantity of data grow, notably with the development of real-time monitoring sensors. These issues are encountered in MULTISOURCE European project which aims to implement an integrated decision-making support tool for NBS implementation in cities for better urban water management. This paper explores a solution for integrated representation of knowledge on NBS.

Knowledge representation

Ontologies are a solution to these issues. Ontologies are explicit, formal and shared representations of knowledge (Uschold and Gruninger, 1996, Hepp et al., 2008). They facilitate communication between agents and interoperability between devices. In particular, they allow standardization of terminologies and classification of concepts.

Ontologies are structured graphs of relations, semantic networks with core constituting elements called semantic triple units. These are formed by two concepts and one relation linking them: *Subject – Predicate – Object*. A given concept can be related to multiple other concepts.

Ontologies can therefore describe a field of knowledge by gathering and connecting different forms of knowledge and domains. Concepts range from abstract to more tangible: more abstract concepts are named upper concepts and constitute the structure of the ontology. They can be applied to multiple cases while most specific concepts are called instances and constitute practical knowledge (or data).

MATERIAL&METHODS

Ontology construction

The development of the ontology followed a 7-step methodology (Noy and McGuinness, 2001) A particular focus was given on:

Reusing chunks of existing ontologies

Some ontologies have been implemented for water management and water quality (Cabezut-Boo and Sánchez-Aguilar, 1999, Ahmedi et al., 2013, Oliva-Felipe et al., 2017), they have been used as basis for decision-making support tools and for modelling but NBS have not been included yet.

Improving terminology: classification and standardization

NBS TU are subject to terminology confusions. Some classifications have been done based on NBS (in particular TW) implementations (extensive, vertical), hydrology functioning (flow direction), and type of vegetation (Fonder and Headley, 2013, Fletcher et al., 2015, Snep et al., 2020) and some standard terminologies have been defined after an expert workshop (Castellar et al., 2021). Available French translations will be added (Chocat et al., 2022). A workshop took place to better settle usual terminology and classification of NBS in the framework of MULTISOURCE first annual meeting. Most specific concepts (instances) are for example MULTISOURCE technical pilots.

Developing the core ontology: treatment chain and mechanisms

Ontology construction focuses on water treatment by NBS technological units (TU) and more specifically, TW. A global structure of a Treatment Chain composed of successive and/or parallel steps was built, adapted from PO2 product transformation processes (Munch et al., 2022). A Treatment Step corresponds to an NBS TU. Expert knowledge on TW functioning was gathered from literature and first-principles models to extract knowledge on treatment mechanisms.

Implementation

NBS hierarchical classification was implemented in the software Protege that supports OWL language to represent ontologies. A resource description framework (RDF) to structure data is available and allows addition of definitions, synonyms and translations of concepts. Building an ontology is an iterative process, feedback from experts will be obtained at two future MULTISOURCE annual meetings for improvements.

RESULTS/DISCUSSION

Improving terminology on NBS

NBS classifications have been merged together and revised after a workshop in the framework of a first MULTISOURCE annual meeting, NBS considered in (IWA, 2021) and synonyms have been added. The first feedback from experts showed diverging arguments on classification of NBS

leading to the choice to use the criteria for hierarchically classifying TW as attributes in the ontology.

Core ontology: description of a treatment chain

Water treatment process structure is described with global concepts (see Figure 1.) and each is related to an “observation” concept which will gather experimental data.

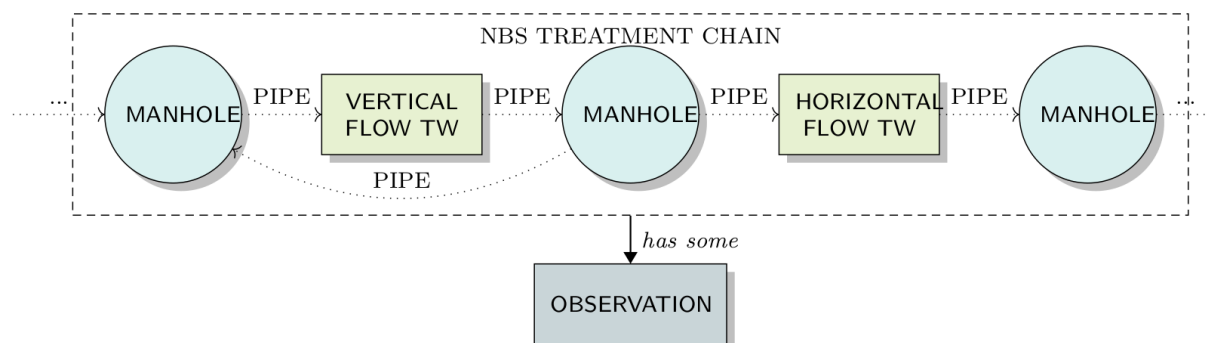


Figure 1. Core ontology is focused on a wastewater treatment chain. The treatment chain is composed of successive and/or parallel nodes: treatment steps (here, VF and HF Treatment Wetlands), pipes and manholes. Each class (here in capital letters) possesses attributes/properties.

Core ontology: description of mechanisms

For each NBS TU and pollutant, knowledge on treatment mechanisms involved and corresponding models through explicit relations in the ontology (see Figure 2.).

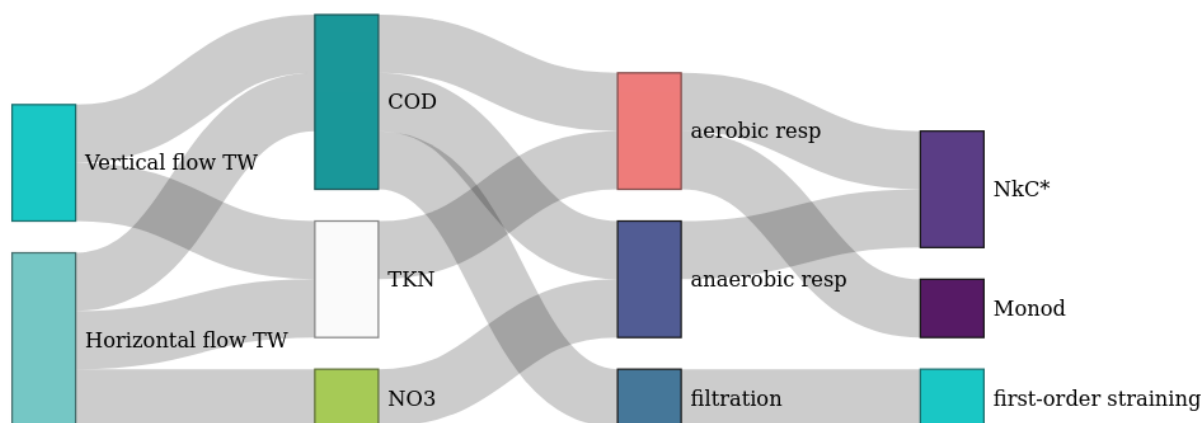


Figure 2. Relations between NBS TU (here VF and HF Treatment Wetlands), pollutants, mechanisms involved and corresponding models.

CONCLUSION

An ontology was built for describing urban water management using NBS, from compiled expert knowledge and data. Knowledge and data were structured and vocabulary standardized. The core of the ontology describes a wastewater treatment chain with successive treatment steps (NBS TU) and resulting effluents. It is a flexible structure that will allow representation of knowledge for multiple case studies. Multiple fields will be gathered: economical analysis, life-cycle analysis, geographical information, NBS TU.. Interaction of these different fields will allow structuration of a common database and allow agents to draw inferences, ie. expliciting implicit knowledge, notably for modelling purpose.

This ontology will be subject to evolution (improvements) over time from iterative feedbacks from experts and agents. Growth of the ontology can be expected with the inclusion of more knowledge from the different fields of expertise. Hopefully, this ontology can be used as a basis for a shared database, for a decision-making support tool and for NBS modelling purpose.

In a context of circularity, the water treatment chain can be seen as a biorefinery for product transformation, where the effluent and byproducts obtained after each step can be reused or valorized. In that case, merging of this ontology with INRAE Transform Ontology could be considered for more interoperability.

REFERENCES

- Cabezut-Boo, O., Sánchez-Aguilar, A., 1999. Towards an ontology of waste water treatment plants: the identification phase. *Environmental Modelling & Software* 14, 401–408. [https://doi.org/10.1016/S1364-8152\(98\)00103-0](https://doi.org/10.1016/S1364-8152(98)00103-0)
- Castellar, J.A.C., Popartan, L.A., Pueyo-Ros, J., Atanasova, N., Langergraber, G., Säumel, I., Corominas, L., Comas, J., Acuña, V., 2021. Nature-based solutions in the urban context: terminology, classification and scoring for urban challenges and ecosystem services. *Science of The Total Environment* 779, 146237. <https://doi.org/10.1016/j.scitotenv.2021.146237>
- Ceccaroni, L., Cortes, U., Sanchez-Marre, M., 2001. WaWO - An ontology embedded into an environmental decision-support system for wastewater treatment plant management 10.
- Chocat, B., Cherqui, F., Afrit, B., Barjot, G., Boumahdi, M., Breil, P., Brelot, E., Celerier, J.-L., Chebbo, G., de Gouvello, B., Deutsch, J.-C., Gachelin, C., Gromaire, M.-C., Hérin, J.-J., Jairy, A., Maytraud, T., Paupardin, J., Pierlot, D., Rodriguez, F., Sandoval, S., Tabuchi, J.-P., Werey, C., 2022. Contribution à une meilleure explicitation du vocabulaire dans le domaine des solutions dites “alternatives” de gestion des eaux pluviales urbaines. *ASTEE*.
- Fletcher, T.D., Shuster, W., Hunt, W.F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J.-L., Mikkelsen, P.S., Rivard, G., Uhl, M., Dagenais, D., Viklander, M., 2015. SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal* 12, 525–542. <https://doi.org/10.1080/1573062X.2014.916314>
- Fonder, N., Headley, T., 2013. The taxonomy of treatment wetlands: A proposed classification and nomenclature system. *Ecological Engineering* 51, 203–211. <https://doi.org/10.1016/j.ecoleng.2012.12.011>
- IWA, 2021. Nature-Based Solutions for Wastewater Treatment - A series of factsheets and case studies.
- Langergraber, G., Castellar, J.A.C., Andersen, T.R., Andreucci, M.-B., Baganz, G.F.M., Buttiglieri, G., Canet-Martí, A., Carvalho, P.N., Finger, D.C., Griessler Bulc, T., Junge, R., Megyesi, B., Milošević, D., Oral, H.V., Pearlmutter, D., Pineda-Martos, R., Pucher, B., van Hullebusch, E.D., Atanasova, N., 2021. Towards a Cross-Sectoral View of Nature-Based Solutions for Enabling Circular Cities. *Water* 13, 2352. <https://doi.org/10.3390/w13172352>
- Masi, F., Rizzo, A., Regelsberger, M., 2018. The role of constructed wetlands in a new circular economy, resource oriented, and ecosystem services paradigm. *Journal of Environmental Management* 216, 275–284. <https://doi.org/10.1016/j.jenvman.2017.11.086>
- Noy, N.F., McGuinness, D.L., 2001. Ontology Development 101: A Guide to Creating Your First Ontology 25.
- Snep, R.P., Voeten, J.G., Mol, G., Van Hattum, T., 2020. Nature Based Solutions for Urban Resilience: A Distinction Between No-Tech, Low-Tech and High-Tech Solutions. *Front. Environ. Sci.* 8, 599060. <https://doi.org/10.3389/fenvs.2020.599060>