IA301 – PROJECT – WATER BODY ONTOLOGY

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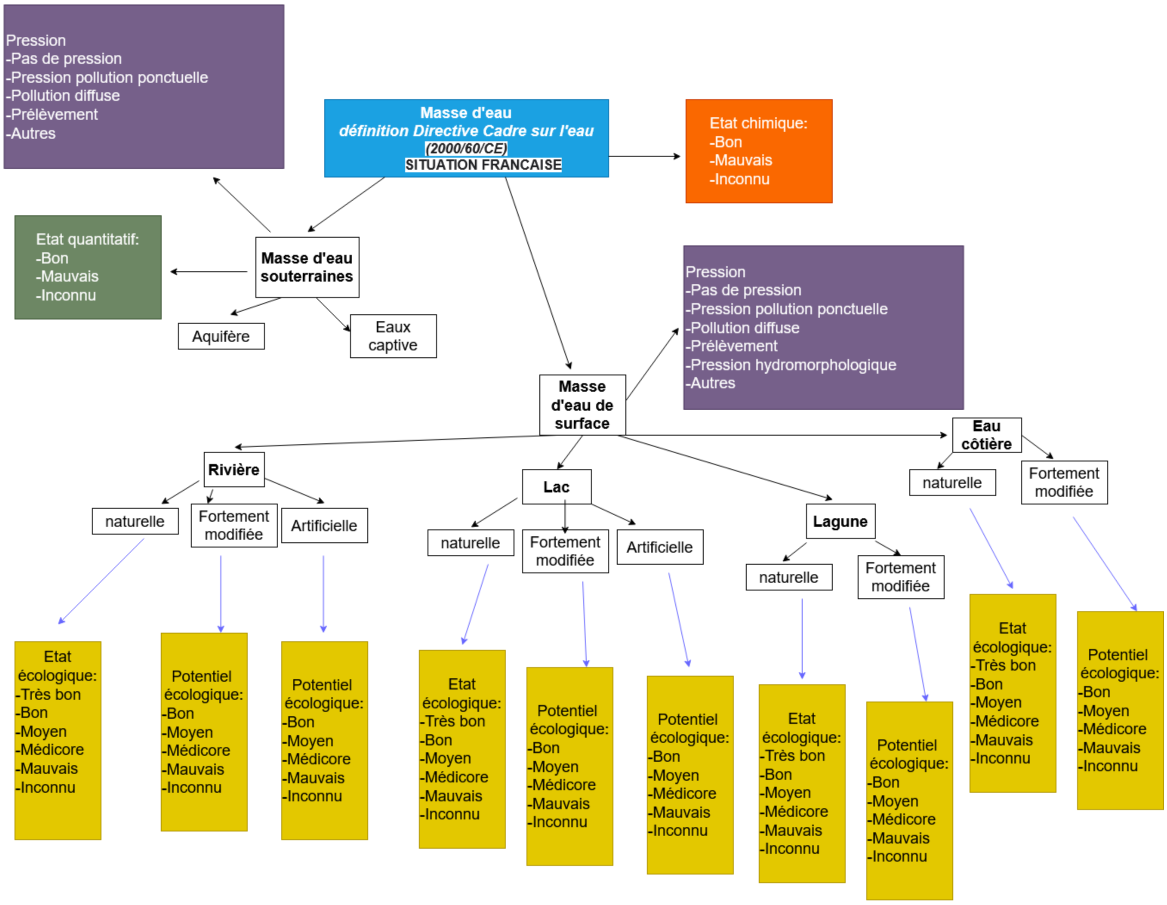
Downloadable at: https://github.com/salvogalata/WaterBody-Ontology-IA301-2020

Graphical description of the ontology domain[1]:



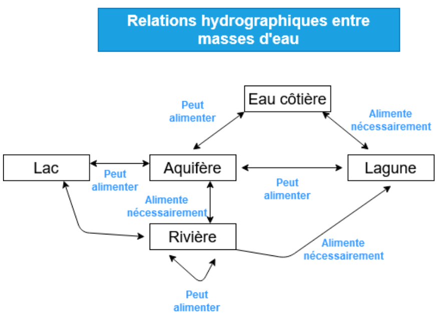


Figure 1 The graphs representing the domain our ontology has to model.

[1] Original domain info source :https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=LEGISSUM%3Al28002b

Description of the ontology

This ontology describes bodies of waters. A water body, in the meaning of the Water Framework Directive (see section devoted to the description of the methodology) can be:

- a lake
- a river
- a coastal water
- a lagoon
- a groundwater: either an aquifer (not confined) or a confined one

A body of water has the following properties:

- Degree of artificiality (natural, artificial, heavily modified)
- Ecological status (good, average, poor, bad, unknown): expresses the quality of the structure and functioning of aquatic ecosystems associated with surface waters.
- Chemical status (good, bad, unknown): related to the chemical pollution of the body of water.
- Quantitative status (good, bad, unknown): expresses the degree to which a body of groundwater is affected by direct and indirect abstractions.

A body of water can feed (be fed) water to (by) one or several other bodies of water.

A body of water is also characterized by a "Pressure" intended as an anthropogenic pressure, i.e. human originated external factors that can significantly influence the status of a body of water. These pressures can be:

- a diffuse pollution
- a point of pollution
- hydromorphological pressure[2]
- abstraction, i.e. water removal by human activities.

How this ontology may prove useful

We decided to work on the Sustainable Development Goal (SDG) 6[3] : « Clean Water and sanitation » and more precisely on the Goal **6.3** which is : « By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally » ; Indeed, poor water quality poses risks to public health, and ecosystem services and function : each day, nearly 1,000 children die due to preventable water and sanitation-related diarrheal diseases . In 2017, an estimated 3 billion people world-wide lacked the ability to safely wash their hands at home – one of the cheapest, easiest and most effective ways to prevent the spread of diseases like the coronavirus.

Water is essential not only to health, but also to poverty reduction, food security, peace and human rights, ecosystems and education. Nevertheless, countries face growing challenges linked to water scarcity, water pollution, degraded water-related ecosystems and **cooperation over trans-boundary water basins**.

Indicator used with the Water Framework Directive (WFD)[4] reporting:

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[2] A hydromorphological pressure is a change to the physical habitat, and/or a water bodies' natural functioning caused by, for example, channelisation which is the dredging and straightening of rivers, land drainage, or hard infrastructure such as dams, weirs, barriers, locks, embankments, culverts, piers, ports and sea walls.

[3] https://www.un.org/sustainabledevelopment/water-and-sanitation/

[4] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"

The indicator we worked on is:

*6.3.2 : « **Proportion of bodies of water with good ambient water quality** ».*

Each country must define "good ambient water quality" and set its own standards and targets based on its specific conditions. These should ensure the aquatic ecosystem is healthy, and that there is no unacceptable risk to human health arising from intended use of the water without prior treatment. The selected core parameters for indicator 6.3.2 are simple to measure and are a good starting point for countries with less-developed monitoring capacities. The methodology allows countries to increase the sophistication of their submissions by including additional parameters, using supplementary methods of assessing water quality such as biological methods and remotely sensed data, and by encouraging countries to expand their monitoring networks over time.

The 2017 baseline data drive for indicator 6.3.2 resulted in 48 country submissions. Thirty-two countries reported on 15,056 open water bodies, 37 on 36,142 rivers and 27 on 8,993 groundwater bodies. Twenty-four countries reported on all three water body types, nine on two types and six on one type.[5]

Most of them are European countries. Indeed, the WFD is in force in the European Union and required the achievement of the ecological status and the chemical status for the surface waterbodies and the quantitative and chemical status in the groundwater in 2015 (exemptions granted). **WFD is based on the DPSIR** (Drivers, Pressures, Status, Impact, Responses) approach. It means that Divers (e.g.: industries, agriculture or population) create pressures (e.g.: point or diffuse pollution, abstraction…) and determine a status (e.g.: good or bad ecological status). Reponses (e.g. measures such as building waste water treatment plants or new regulation on water prices…) are planned by countries to tackle these pressures and thus achieve the good status of the water body.

The indicators developed for the WFD status are complex indicators mixing physic-chemical, biological and chemical parameters. This experience can be used in the context of the UN Goals and indeed, UN, the European Commission, the European Environmental Agency and the members States of the European Union work together to improve the reporting of the UN-indicator.

How our ontology could help?

Lack of information, or inaccurate information for this indicator could lead to incorrect management actions, such as:

- Lack of appropriate controls on discharges to waterbodies
- Inadequate treatment to waters used for drinking water supplies
- Delayed or inadequate conservation or remediation of waterbodies and wetlands

The main interest of this ontology is its use on a global scale. The WFD in Europe is well advanced but in many countries in the world the challenge in monitoring, storing and evaluating the data is huge. This experience could be used to make inferences to help countries lacking methodologies or data.

Our ontology makes the link between waterbodies upstream and downstream. The cases of transboundary water bodies is a crucial issue, often leading to transborder conflicts. Thanks to this ontology, inferences could be made to deduce the status of downstream water bodies. It could give information to some countries about the status of their water bodies and the source of the pollution. Entire population are impacted by pollution coming from other regions or countries upstream.

[5] Source : SDG6_SynthesisReport2018_WaterandSanitation_04122018_

The link between pressures and this status could also be used to help countries that lack of monitoring data but have data on pressures (other sources of data could also be used e.g. satellite data…). Status of water bodies could be modelled.

In conclusion: pollution, climate change, conflicts, water-related disasters and demographic shifts are putting unprecedented pressure on water resources in many regions of the world. More information on these complex linkages will improve the performance of decision makers.

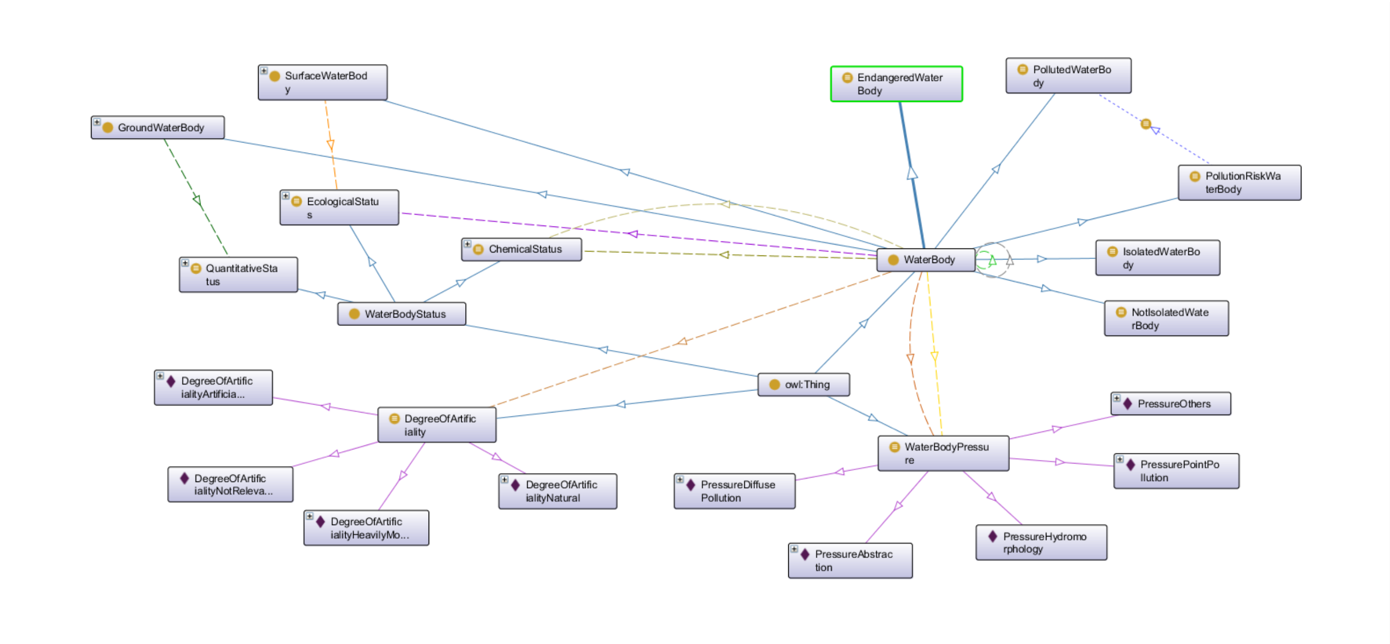
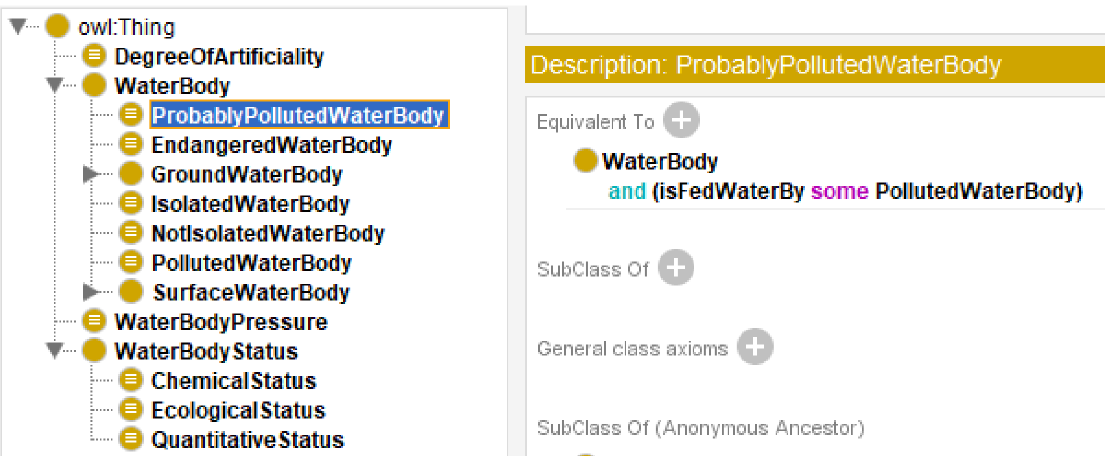


Figure 2 Ontology graph (a part): the water bodies are grouped on the upper right corner and their attributes are grouped on the left and the bottom,

the arrows show the object property relations between them.

Useful Inference 1:

The class *ProbablyPollutedWaterBody has been defined like below :*



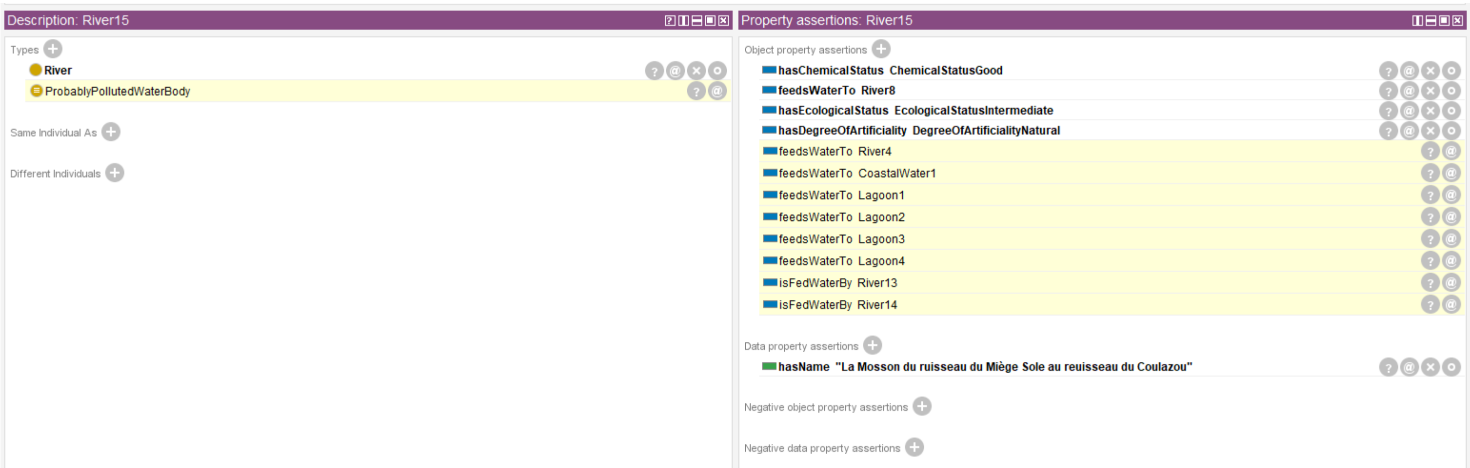
This class basically defines the individuals that are fed by a water body that is found to be polluted.

Let’s take the case of River15, which is fed by River13 who in turn is fed by River14.

The reasoner will infer the following things:

1. The entire feeding chain connected to River15, both upstream and downstream
2. Since River13, which is upstream, is found to be a *PollutedWaterBody,* River15 is assigned to the class *ProbablyPollutedWaterBody*

as can be seen below :



Therefore, the ontology can automatically classify all the water bodies that, because they are fed by a polluted water body are probably also polluted.

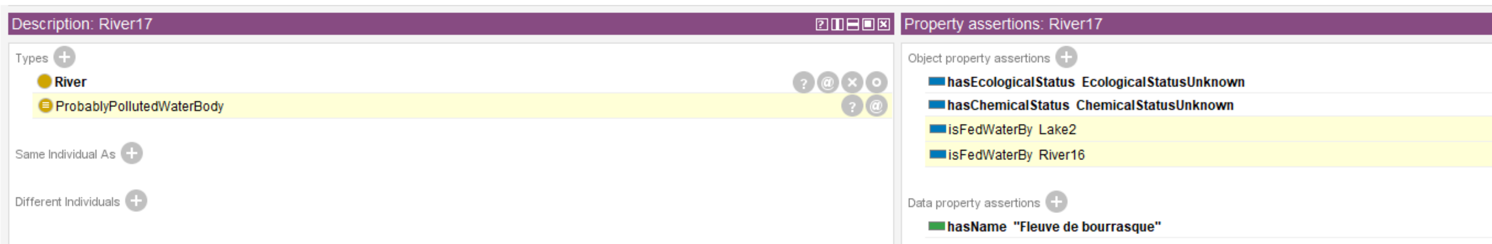
Useful Inference 2 :

Let' s assume we have the following situation :

- Lake2 is polluted and feedsWaterTo River16
- River16 feedsWaterTo River17

Since the relation "feedsWaterTo" is **transitive**, if Lake2 feedsWaterTo River16 and River16 feedsWaterTo River17, then Lake2 feedsWaterTo River17.

Therefore, River17 is also probably polluted as can be seen below :



Then , the reasoner will infer that River17 belongs to the class *ProbablyPollutedWaterBody.*

Ontology data and examples of concrete queries applied to the use case

In order to prove our ontology usefulness in the use case it was conceived for, i.e. the management and assessment of water bodies, we have inserted the data of around 20 water bodies in France (groundwaters, rivers, lakes and lagoons), some of which are interconnected. For the data insertion we have used the cell-fie plugin, that eased the import from our excel spreadsheet (the data and the rules are in the github repository). This allows us to show that the ontology can answer various questions regarding water bodies of a region, potentially up to the scale of a country if the data is loaded. In the following figures are shown some example screenshots of queries that we have tested in our ontology (explanation to be found in each figure's caption). The ontology is capable of answering questions concerning water bodies status, or involving the knowledge about the interconnections between water bodies and the direction of the flow. In

Figure 4 is shown a somewhat complex query that would allow an operator to spot those water bodies that are suffering from pollution deriving from a known human activity. We think that this is of great potential and, even in its simple form, would provide a tool of unprecedented inference power with respect to those currently used by the people involved in this sector.

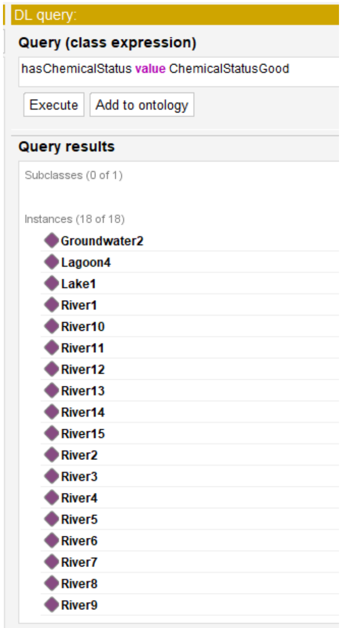


Figure 2 The above query answers the question:

what bodies of water have a good chemical status ?

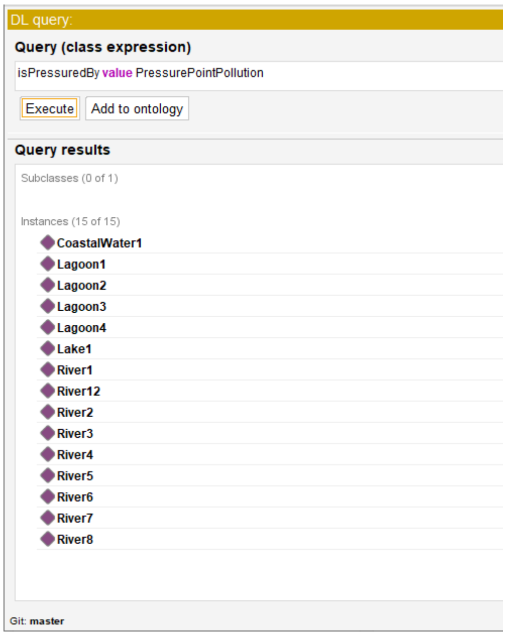


Figure 3 The above query answers the question : what bodies of water are pressured by a polluted environment or a factory?

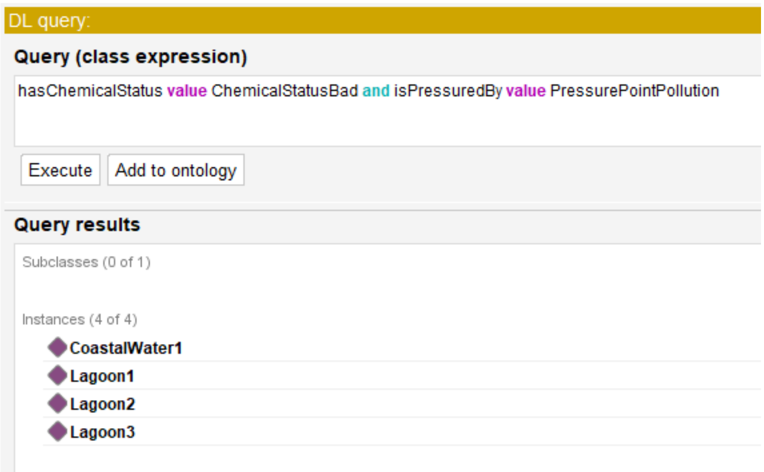


Figure 4 The above query retrieves the bodies of water that are indeed polluted (bad chemical status) and that are influenced/contaminated by polluted environments or human activities.

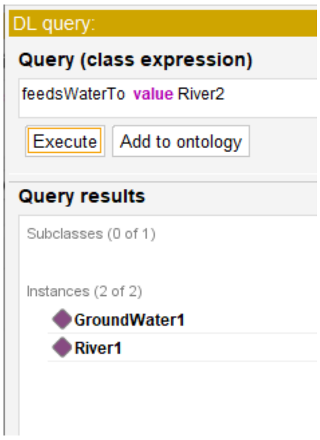


Figure 5 Example query to answer the question : what bodies of water supply water to River2?

Justifications for ontology design

As described in the first paragraph, the ontology includes two main blocks of concepts: the water bodies on one side and their attributes on the other. The attributes are in turn split in three separate concepts such to express the status (ecological, chemical and quantitative), the degree of artificiality and finally the anthropogenic pressure exerted. The object properties relating a water body to its attributes have also been defined. Some of them are functional, like the "has*Status" properties, or the "hasDegreeOfArtificiality". On the other hand, the "isPressuredBy" relation is not functional, since several human activities can impact one water body at the same time. Object properties relating water bodies between them have been created to express the direction of water flow, through the relations "feedsWaterTo" and its inverse "isFedWaterBy", both transitive. To express the fact that Lagoons and CoastalWaters can feed water to each other mutually, we have created an additional object property called "exchangesWaterWith", whose domain and range is limited to Lagoon and CoastalWater only. We finally created the actual instances of the attributes, so that we could relate them to water body instances.