# Modelling a severe transient anoxia of continental freshwaters due to a Scheldt accidental release (sugar industry)

## Modélisation d'une anoxie transitoire sévère résultant d'un rejet accidentel sur l'Escaut (industrie sucrière)

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## RÉSUMÉ

La plupart des pollutions anthropiques peuvent être évaluées, telles que les rejets domestiques et industriels, les charges provenant de l'agriculture, … Toutefois, certaines d'entre elles, qui sont associées à des rejets illégaux, des accidents industriels, … sont plus difficiles à prévoir. L'accident de l'industrie sucrière Tereos est survenu dans la nuit du 9 avril 2020. Quatre-vingt-huit mille mètres cubes d'effluents chargés en matières organiques ont été déversés dans l'Escaut (cours d'eau transnational de 350 km de long qui traverse le nord France et l'ouest de la Belgique). L'accident a eu des conséquences dramatiques sur la rivière réceptrice, sur une distance de plus de 120 km en aval. Des mortalités de poissons ont été observées et une désoxygénation sévère, atteignant une concentration nulle en oxygène dissous, a eu un impact sur la qualité chimique de la rivière. L'objectif est de comprendre et décrire la dynamique de la pollution chimique et sa propagation le long du réseau hydrographique transfrontalier de l'Escaut. Une méthode basée sur les processus de dégradation de la matière organique dans l'écosystème fluvial a été améliorée. Il est démontré que l'accident est sans doute à l'origine de la désoxygénation de la colonne d'eau. Ce papier montre comment la modélisation de la qualité de l'eau peut aider à comprendre et donc à prévenir les conséquences d'une pollution accidentelle sur un bassin versant.

## ABSTRACT

Most anthropogenic pollution can be controlled, such as domestic and industrial releases, loads from agriculture, etc. But some of them, which are associated to illegal discharges, industrial accidents, etc. are more difficult to forecast. The Tereos sugar industry accident occurred during the night of 9th April, 2020. Eighty-eight thousand cubic meters of effluents loaded with organic matter discharged in the Scheldt river (a 350 km-long transnational river which flows through northern France and western Belgium). The accident had dramatic consequences on the receiving watercourse, over 120 km downstream. Fish mortalities have been observed and severe deoxygenation, reaching zero concentration in dissolved oxygen, have impacted river chemical quality. The objective was to understand and describe the dynamics of the chemical pollution and its propagation along the transboundary hydrographic network of the Scheldt. A method based on the processes of organic matter degradation in river ecosystem was enhanced. It is demonstrated that the accident is doubtless the cause of the water column deoxygenation. This paper shows how the water quality modelling can help to understand and therefore to prevent the consequences of an accidental pollution on a watershed.

## MOTS CLES

industrial accident, modelling, pollution, sugar industry, water quality

# 1 INTRODUCTION

During the night of 9th April, 2020, a dike of a settling pond was broken in the Tereos sugar refinery in Escaudoeuvres (North of France). This accident resulted in a release of beet washing waste water very rich in organic matter. This washing water discharge quickly saturated the aquatic environment. Severe deoxygenation have been observed in the rivers of the Scheldt Transnational District and reproduced by a modelling method.

# 2 MATERIALS AND METHODS

## 2.1 Data

The volume of stored water in the settling pond of the Tereos sugar industry was 108 000 m³. Due to the breakage of the pond, around 88 000 m³ of beet washing water discharged into the Raperie watercourse which flows into the Erclin, near its confluence with the Scheldt.

The COD concentrations measured in the river that received the unexpected industrial wastewater were 7399 $mgO_2/l$ and the dissolved oxygen collapsed to 1.23 mg/l on 10th April. Data measurements showed that the release has lasted 30 hours.

## 2.2 Method

### *2.2.1 Mathematical Representation*

The main processes involving organic matter in a river ecosystem are represented in the POMD method (Processes of Organics Matter Degradation). This method is applied to the entire and spatially discretized hydrographic networks of the Scheldt District.

The dissolved organic matter and the fine particulate organic matter are transported downstream by the flow. They are progressively decomposed by the suspended heterotrophic bacteria and the biofilm present on the bottom. The part of the organic carbon is assimilated by bacteria, the rest is transformed into $CO_2$. This oxidation is accompanied by the consumption of oxygen. Anaerobic processes in the water column are also considered in the organic matter cycle representation.

### *2.2.2 Scheldt Application*

The Scheldt District application (Figure 1) has been used to (i) simulate the industrial accident, (ii) assess the consequences of this large-scale pollution and (iii) serve as a management tool for the Administrations concerned by this pollution.

The accidental release from the Tereos settling pond is simulated as a series of constant releases over a period of 3 hours. When the release stopped, the cumulated volumes were about 89 100 m³.

The simulations allow calculating at an hourly timescale the evolution in April 2020 of dissolved oxygen concentrations, chemical oxygen demand, biochemical oxygen demand, organic carbon and concentrations of the different forms of nitrogen and phosphorus.

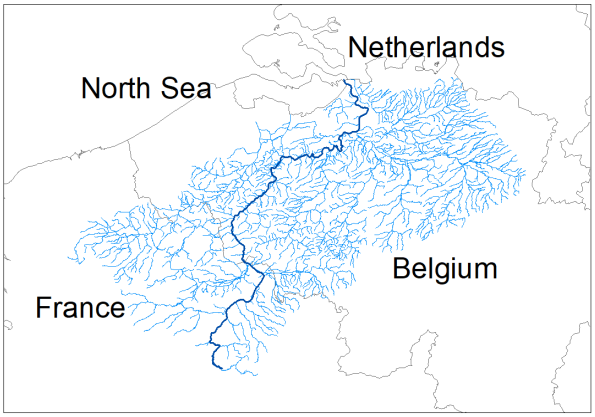


Figure 1: Transnational District of the Scheldt (the Scheldt river is highlighted)

# 3 RESULTS AND DISCUSSION

## 3.1 Organic matter

On the French part of the Scheldt, the simulation results show a very high organic matter load in the Scheldt water column. The COD concentration in the Scheldt (at the location of the accidental release) reached 1700 $gO_2/m^3$ in the early hours of 10th April.

Eight kilometers downstream, the COD concentration decreased to 1040 $gO_2/m^3$ on 11th April around 18 PM. Downstream, at the Belgian border, the pollution came on 19th April and had COD

concentrations of 160 $gO_2/m^3$ at the maximum, and 67 $gO_2/m^3$ in Flanders (Ghent) on 27th April.

## 3.2 Deoxygenation

The results show severe deoxygenation in the water column near the accidental release. As the discharge was mainly composed of slowly degradable matters, the pollution spread very far, polluting about 120 kilometers of rivers.

At the location of the accidental release, the dissolved oxygen in the water column drops sharply to 1.5 $gO_2/m^3$ on 10th April at 2 AM. The discharge ends on 11th April at 6 AM and the system recovered with a dissolved oxygen concentration of 9.1 $gO_2/m^3$ on 11th April at 9 AM.

Eight kilometers downstream, the pollution caused also the collapse of dissolved oxygen concentration (0.15 $gO_2/m^3$), with a 40 hours lasting anoxia. The pollution was transported about 7.8 km in 35 hours, that corresponds to 5.3 km/day.

The pollution impacted the Belgian Scheldt between 18th and 19th April. The dissolved oxygen concentration dropped to 1 $gO_2/m^3$. These anoxic conditions lasted until 20th April in early afternoon.

The pollution plume reached Flanders on 27th April at 3 AM and the dissolved oxygen concentration was about 0.85 $gO_2/m^3$ around 28th April at 3 AM.

## 3.3 Describing the transborder pollution

These graphs (Figure 2) represent the overlapping of the COD and dissolved oxygen concentrations calculated on the Scheldt (French part). They allow tracking the pollution that progressed along the river. Successively, the pollution reached stations and cities on the Scheldt river and generated anoxia for many hours.

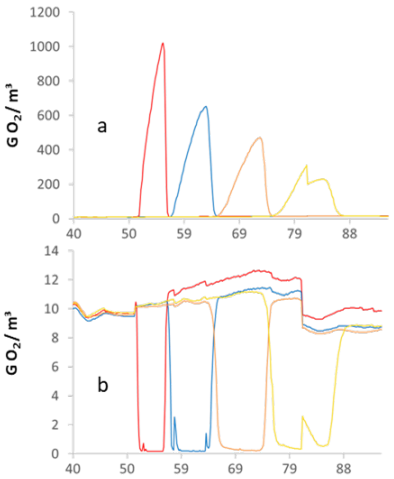


Figure 2: Longitudinal evolution of concentrations calculated on the French part of the Scheldt on 12th, 14th, 16th and 18th April at 11:30 AM: COD (a) and dissolved oxygen (b)

# 4 CONCLUSION

This anoxia did not occur homogeneously and simultaneously throughout the disaster area of the Scheldt. The pollution was transported downstream following the river flows, collapsing the aquatic ecosystem. The scale of this ecological disaster has rarely been recorded (by monitoring network) in Western Europe, as a direct consequence of an industrial accident. The physico-chemical recovery of the aquatic ecosystem followed the same shape of wave front evolution downstream the river. The dissolved oxygen concentrations re-increased and returned to acceptable values for life in a few hours.

The transboundary modelling of the International Scheldt District has allowed better understanding and describing the nature and the dynamics of this pollution in all watercourses.

# BIBLIOGRAPHIE

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