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Combining microscopic and macroscopic diffusion theories to evaluate ^{14}C transfers at the water-atmosphere interface downstream of a nuclear plant

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^{14}C is one of the radionuclides most commonly released into aquatic environments by nuclear facilities. It can then be used to track the speciation and exchanges processes of carbon in rivers. Among the processes conditioning the fate of ^{14}C in the aquatic environment, exchanges at the water-atmosphere interface can play an important role. However, they are poorly understood and poorly estimated from a quantitative point of view.

As regards ^{14}C in a river subject to discharges from a nuclear power plant, we can expect an over-concentration of ^{14}C in the aquatic compartment compared with the atmospheric compartment. However, the prediction of ^{14}C fluxes at the water-atmosphere interface remains difficult insofar as several (unresolved) alternatives are conceptually possible: (i) either ^{14}C (more precisely $^{14}CO_2$) follows its own gradient at the water-air interface; (ii) or ^{14}C (more precisely $^{14}CO_2$) follows the global CO_2 gradient (assuming that $^{12}CO_2$ and $^{14}CO_2$ belong to the same pool of molecules) and degassing depends on the CO_2 gradient between the river and the atmosphere.

However, both approaches are based on a macroscopic theory of diffusion, and more generally of exchanges, at the water-atmosphere interface. The first aim of this work is to criticize these two approaches, identify their limitations and inconsistencies and propose an alternative approach, combining macroscopic and microscopic diffusion theory, i.e. a ‘random walk’ approach.

In order to parameterize and validate the proposed conceptual model, *in situ* experiments were carried out downstream of a nuclear power plant on the Loire during periods of radioactive effluent discharge. Exchange of both radiocarbon and stable carbon at the water-atmosphere interface were measured or estimated through several approches (floating chamber, eddy correlation). Experimental results of these measurement campaigns will be presented and compared to the 'random walk' model and the use of radiocarbon as proxi of stable carbon will be discussed.