Geophysical Research Abstracts
Vol. 19, EGU2017-2314, 2017
EGU General Assembly 2017

Salt tracer experiments in wetland ponds: will density stratification spoil the outcome?

Bernhard H. Schmid (1) and Michael A. Hengl (2)

(1) Institut für Wasserbau und Ingenieurhydrologie, Technische Universität Wien, Vienna, Austria (schmid@hydro.tuwien.ac.at), (2) Institut für Wasserbau und hydrometrische Prüfung, Bundesamt für Wasserwirtschaft, Vienna, Austria (michael.hengl@baw.at)

Wetland ponds are among the treatment options for peatland flows prior to their discharge into a receiving ambient water course or water body. The removal efficiency and effectiveness of wetland ponds (free water surface or FWS wetlands) is considered to be strongly related to the residence time or travel time distribution in the pond, with a narrow distribution (close to plug flow) being preferable to a wider one. This travel time distribution is, in turn, reflected by a breakthrough curve of an ideal tracer injected instantaneously into the flow (entering the wetland). As the term 'ideal tracer' suggests, such a substance, in real world cases, does not exist and can, at best, be approximated by a real tracer. Among the tracer groups in most widespread use, salt has the advantage of low cost, straightforward detection and analysis as well as low related environmental risk. In contrast, use of radioactive artificial tracers may meet with resistance from authorities and public, and fluorescent dyes are not necessarily devoid of problems, either (as recently discovered, there are two structural isomers of Rhodamin WT, the mixture of which may compromise the validity of breakthrough data analyses).

From previous work by the authors it is known that density stratification may result from the injection of a salt tracer into a low Reynolds number free surface flow, which is a frequent characteristic of wetland ponds. As the formation of density layers in the course of a tracer experiment is highly undesirable, it may be useful to judge prior to beginning of the field work, if stratification is to be expected (and the experimental design should, consequently, be adapted suitably). The current work reported here employs an energy argument to extend existing criteria for density stratification in turbulent free surface flows. Vertical mixing is assumed to be sustained by a fraction of the frictional energy loss (expressed by Manning's law, but this can easily be adapted to other friction laws such as Darcy-Weisbach's). Experimental data obtained by the authors in the course of the PRIMROSE project (Contract no. EVK1-CT-2000-00065) were used to calibrate the criterion with respect to the actual percentage of the friction loss that fuels the vertical mixing.

The distance x (m) needed for (full) vertical mixing of the salt tracer (NaCl or KBr) is finally derived as:

$$x = \frac{C_0 \cdot (0.802 - 0.002 \cdot T_w) \cdot h}{0.0694 \cdot \rho_w} \cdot \frac{R_h^{4/3}}{(n \cdot \overline{u})^2} \tag{1}$$

with

$$C_0 = \frac{M_0}{Q \cdot \Delta t_0} \tag{2}$$

and M_0 the tracer mass (g), Q the flow rate (m^3/s), Δt_0 the injection pulse duration (s), R_h (m) the hydraulic radius (= flow cross-sectional area divided by wetted perimeter), T_w the water temperature (°C), ρ_w water mass density (g/m^3), Manning's n in SI-units (s/$m^{1/3}$) and cross-sectionally averaged flow velocity $\overline{u}$ (m/s). Tracer concentration C_0, as obtained from Eq.(2), is to be expressed in mg/l or g/m^3 for use in Eq.(1).