SMARTCHLOR PROJECT

THE INTELLIGENT CHLORINATION SYSTEM

BUDAPEST WATERWORKS

InnoWater

C.Q.M

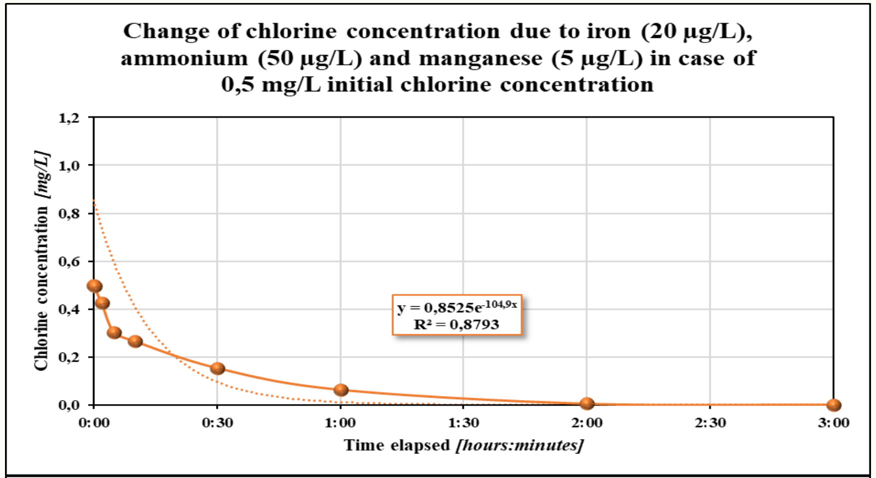
National Research, Development and Innovation Office
Hungary

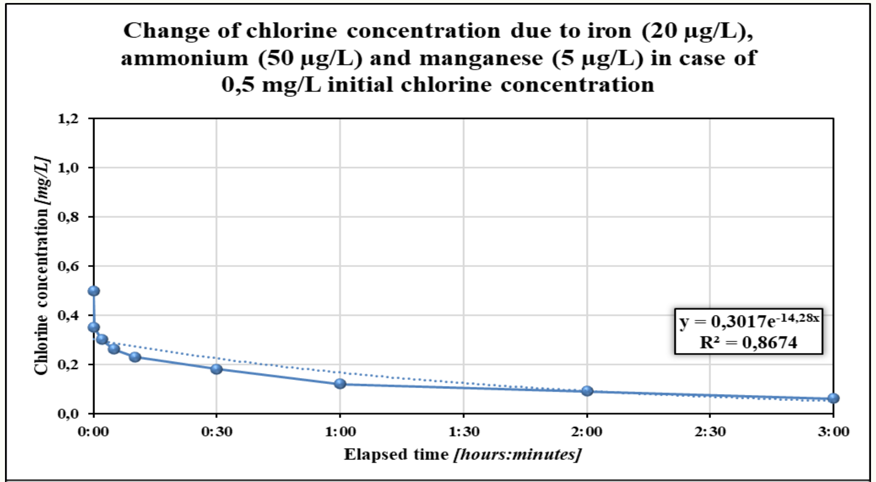
PROJECT FINANCED FROM THE NRDI FUND
MOMENTUM OF INNOVATION

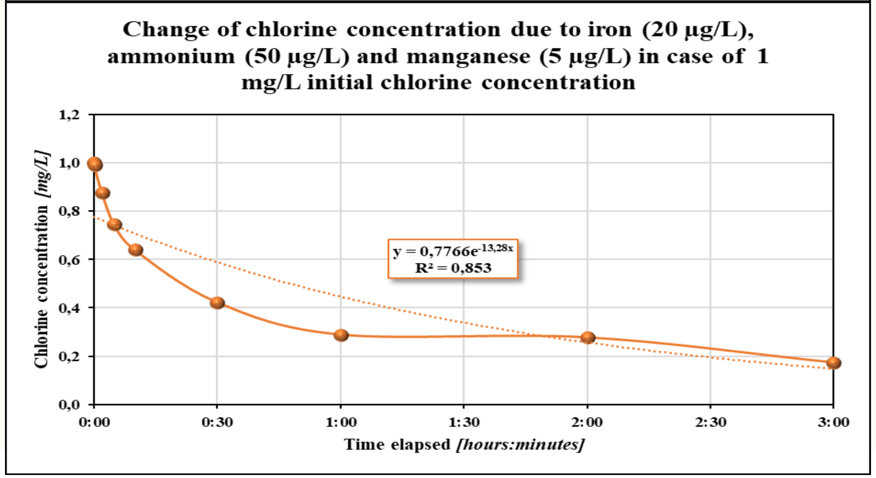
Tasks performed in session 2 - Summary

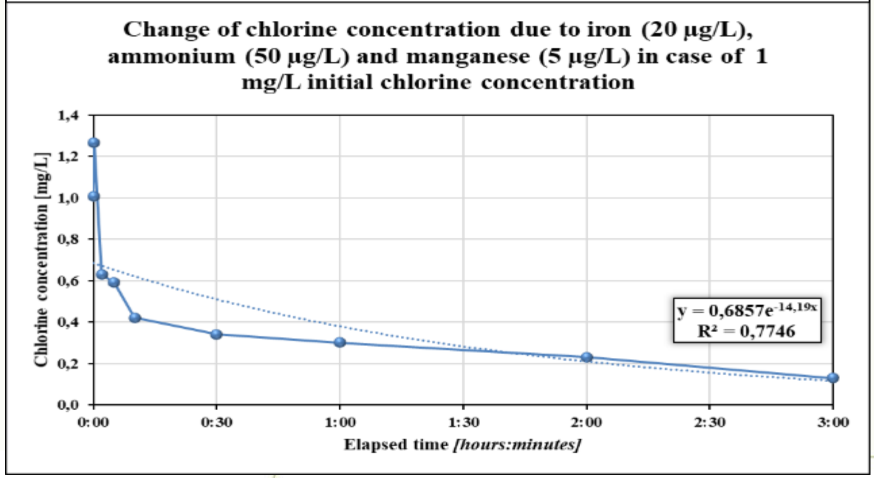
- Laboratory experiments
  - Synergistic effects of dissolved contaminants (NKE)
  - Effect of additional disinfection procedures on chlorine requirement (NKE)
  - Chlorine consumption of the biofilm (IW)
  - Effect of pipe material and pipe-bound biofilm on chlorine decrease (NKE)
- Experiments on the pilot system (FV)
- Field experiments, tests on the network (FV)
- Algorithm improvement, model building, tests (IW)

Laboratory experiments - Synergistic effects of dissolved contaminants









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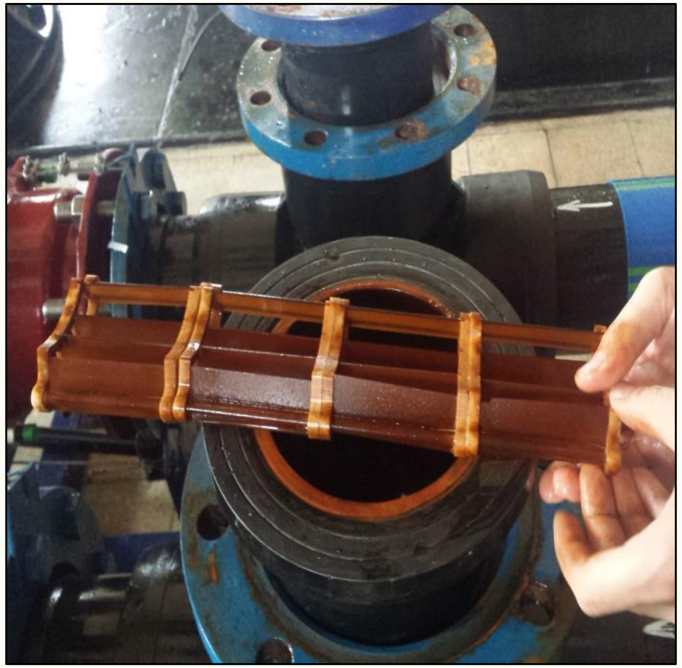
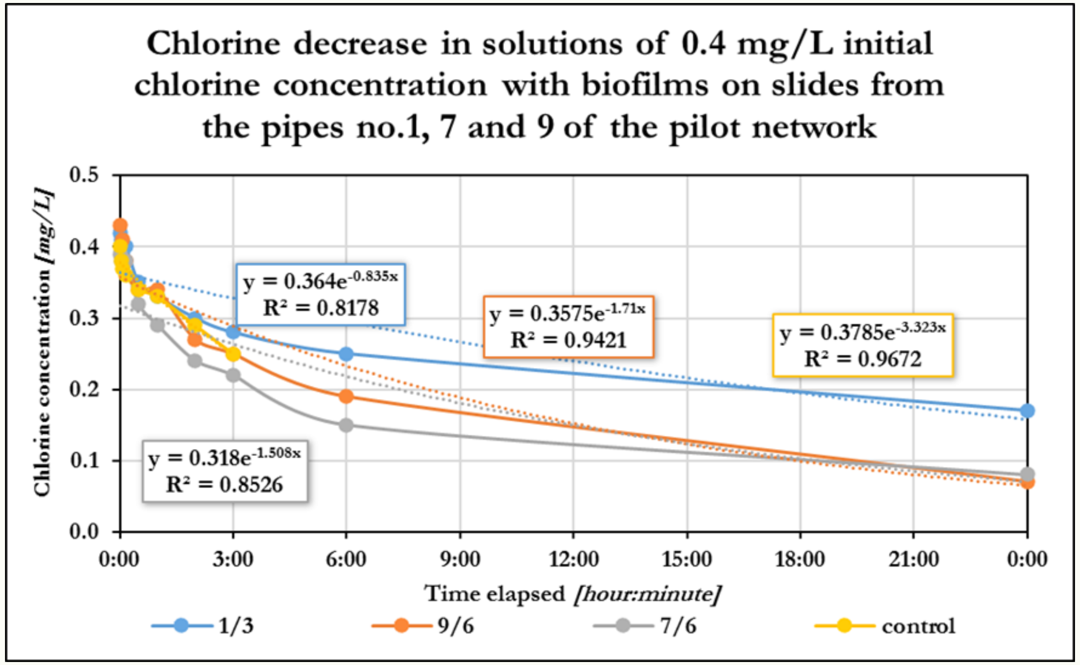
Laboratory experiments - Effect of additional disinfection procedures on chlorine requirement

- reverse osmosis
- ultrafiltration
- ozone treatment
- activated carbon
- biologically active carbon
- sand filtration

Laboratory experiments - Chlorine consumption of the biofilm





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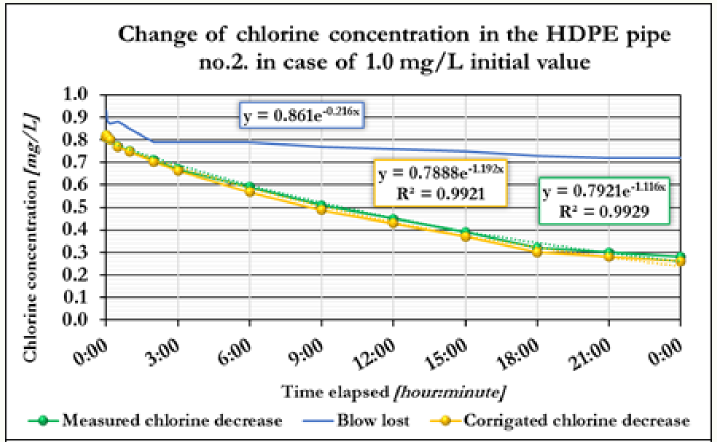
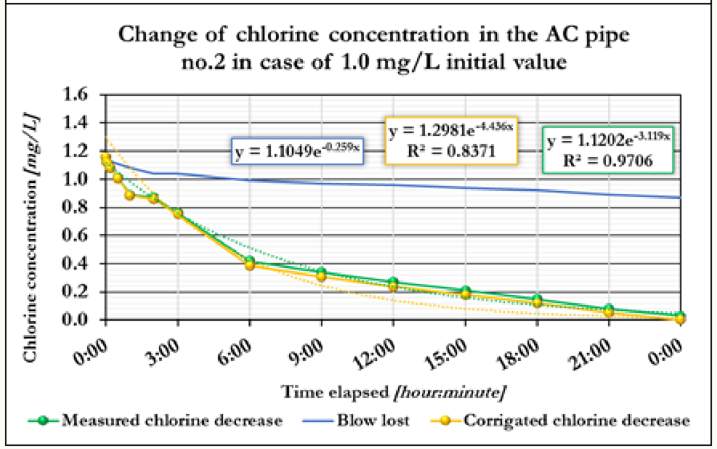
Laboratory experiments - Effect of pipe features on chlorine decrease

Reactor made from HDPE pipe via adhesive and coverage

Reactor made from asbestos-cement pipe via adhesive and coverage





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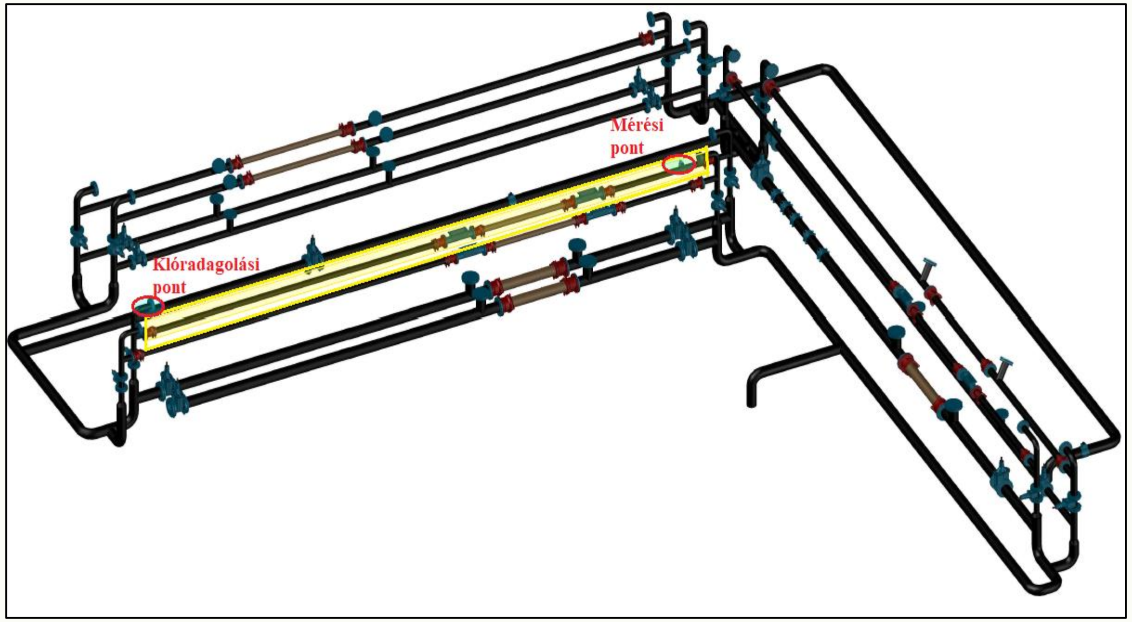
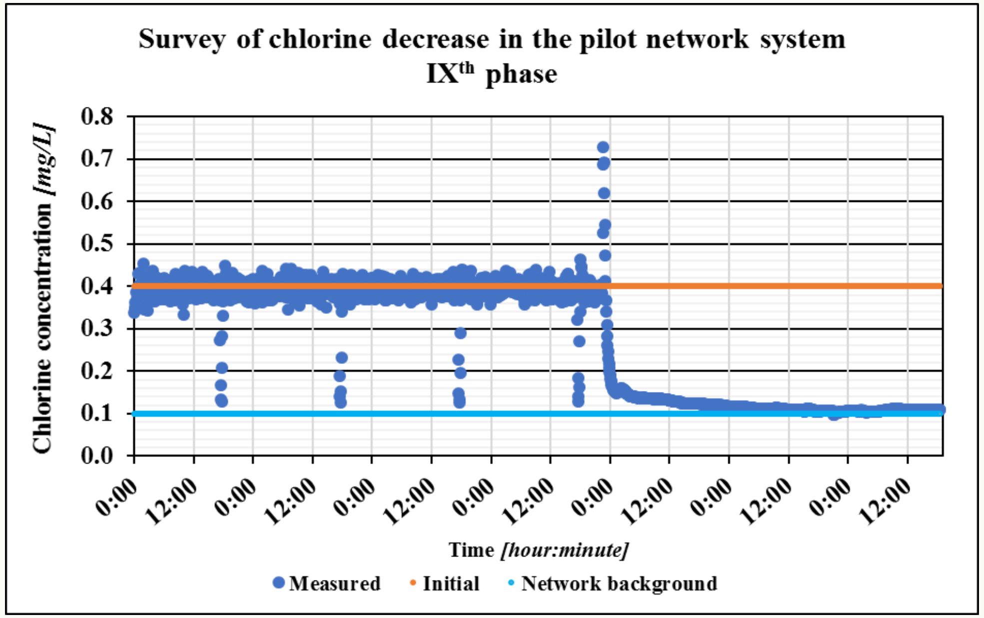
Survey of chlorine decrease in the pilot network system





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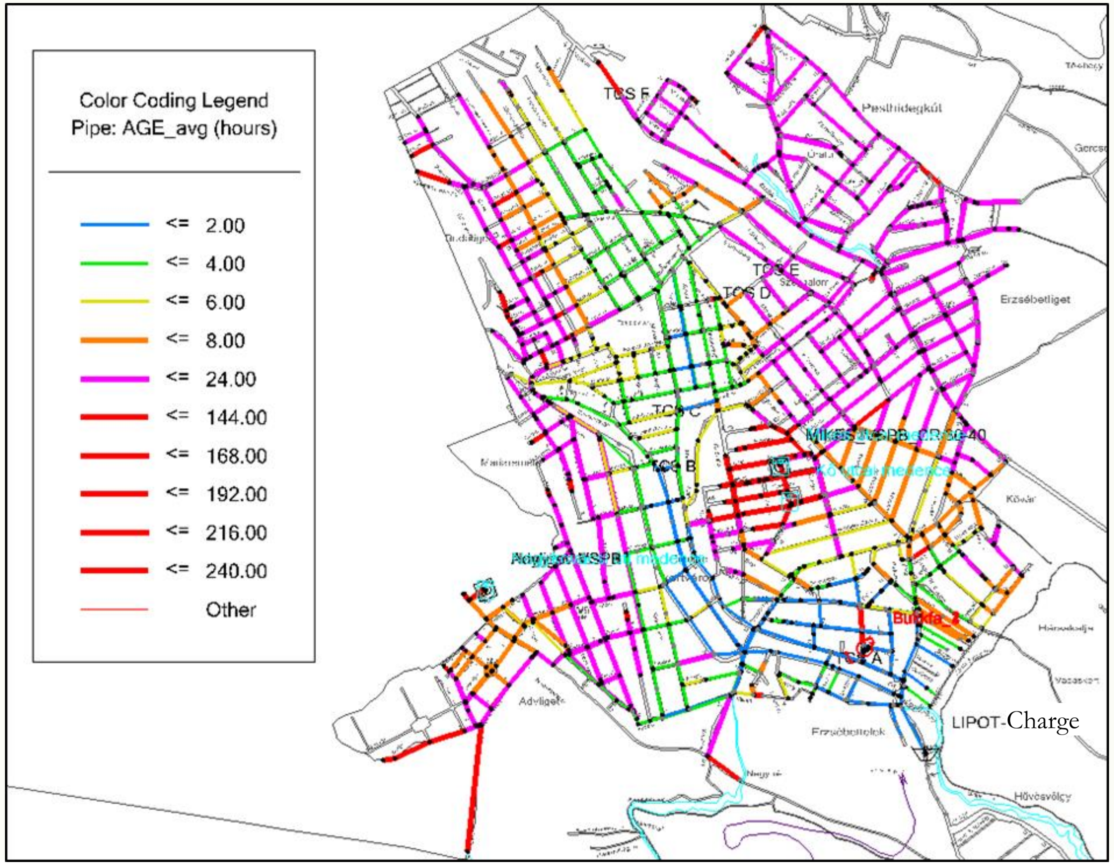
Field experiments – Step 1: Estimated water age



Average 24-hour water age values

Results

- Selection of sampling points
- Planning of the sampling schedule

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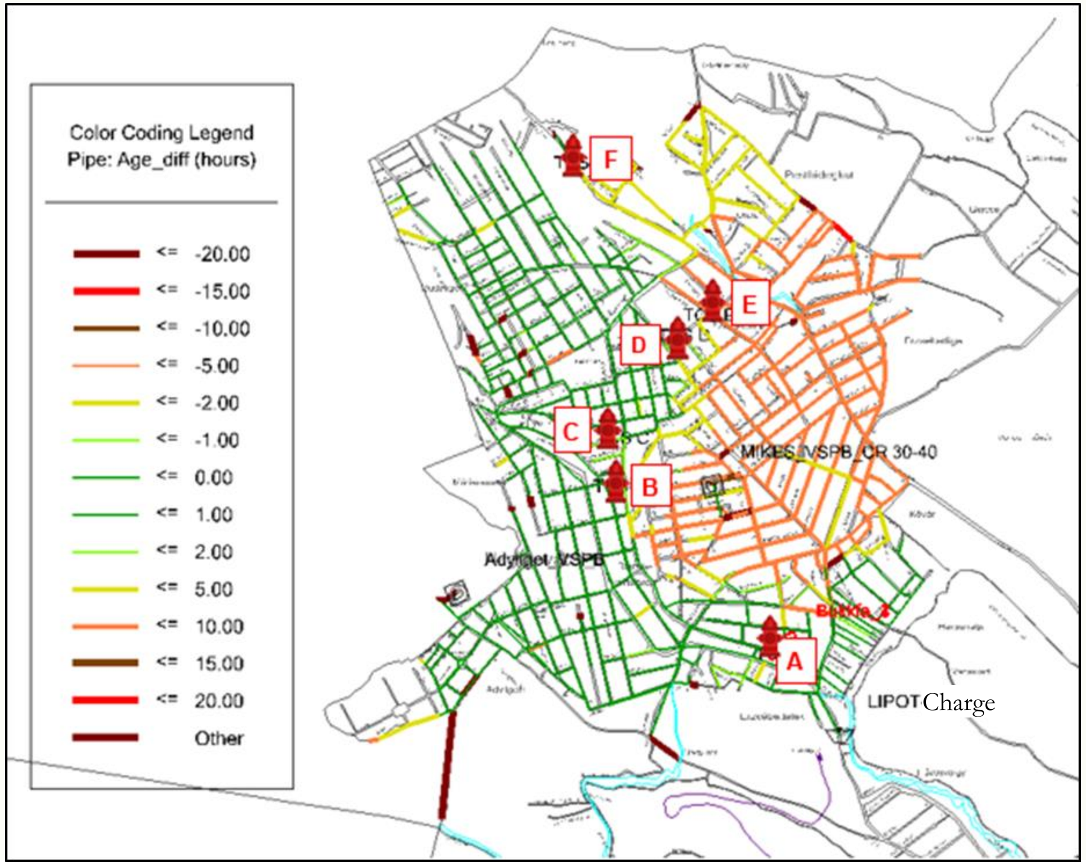
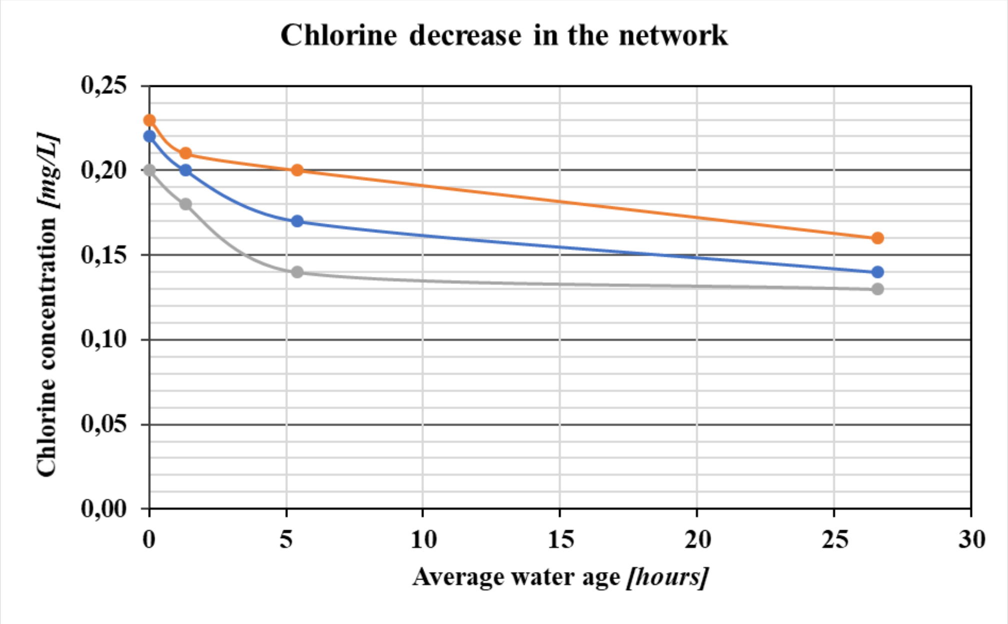
Field experiments – Step 2-3: Real water age chlorine decrease



Estimated and real water age values in the sampling period

Results

- Determination of real watere age
- Calculation of chlorine decrease



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Structure of the developed model

- Sedimentation and transport model
- Chlorine decrease model (solved species: iron, manganese, ammonium)
- Chlorine decrease model (sediment)

Sedimentation and transport model

- Sediment formations

$$\frac{\partial M(MLSS_{sediment})}{\partial t} = |k_1 * v_{avg} + k_2| * v_{avg} * D^3 L * k_3$$

- Sediment resuspension

$$\frac{\partial C(MLSS_{suspended})}{\partial t} = \frac{1}{1 + e^{(-35 v_{átl} + 8)}} C(MLSS_{sediment}$$

$$\frac{\partial C(MLSS_{sediment})}{\partial t} = -\frac{1}{1 + e^{(-35 v_{avg} + 8)}} C(MLSS_{sediment}$$

- Sedimentation of the suspended solids

$$\frac{\partial C(XMLSS_{sediment})}{\partial t} = \frac{v_{ü}\, C(MLSS_{suspended})}{D} \max(0; 1 - \frac{a * \ C_{MLSS\_sediment}}{K_{MLSS\_sediment} + C_{MLSS\ üledék}}$$

$$\frac{\partial C(XMLSS_{suspended})}{\partial t} = -\frac{v_{ü}\, C(MLSS_{suspended})}{D} \max(0; 1 - \frac{a * \ C_{MLSS\_sediment}}{K_{MLSS\_sediment} + C_{MLSS\ sediment}}$$

Chlorine decrease equations in the model describing the effect of solved iron, manganese and ammonium

- **Fe**

$$\frac{\partial Cl}{dt}[hours] = a_1 + a_2 * \mathrm{Fe} * \mathrm{Cl} + a_3 * \mathrm{Cl} + a_4 * (\mathrm{Cl} - a_5)^2 + a_6 * e^{a_7 * (\mathrm{Cl} * \mathrm{Fe} * a_8) + a_9} + a_{10} * e^{a_{11} * (\mathrm{Cl} + a_{12}) * \mathrm{Fe}}$$

Parameters in Fe eq.	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
	1,378	-2	-0,323	-0,6	0,604	0,947	-1,8	8,5	-1,4	-1,38	-0,61	0,264

- **Mn**: no effect

- **NH_4^+**

$$\frac{\partial Cl}{dt}[hours] = a_1 + a_2 * a_6{}^{a_3 * (Cl + a_4 * (Cl - Cl_0 * a_7) + a_5)} * \frac{1}{Cl0^{0.68}} * a_8 * NH4^{a_{10}} + a_9 * 1/(1 * a_{11} + Cl) + 0{,}2$$

Parameters in NH4 eq.	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}
	0,05	-10	1	17	-3,28	1,8	0,9	4	-0,2	1	0,9

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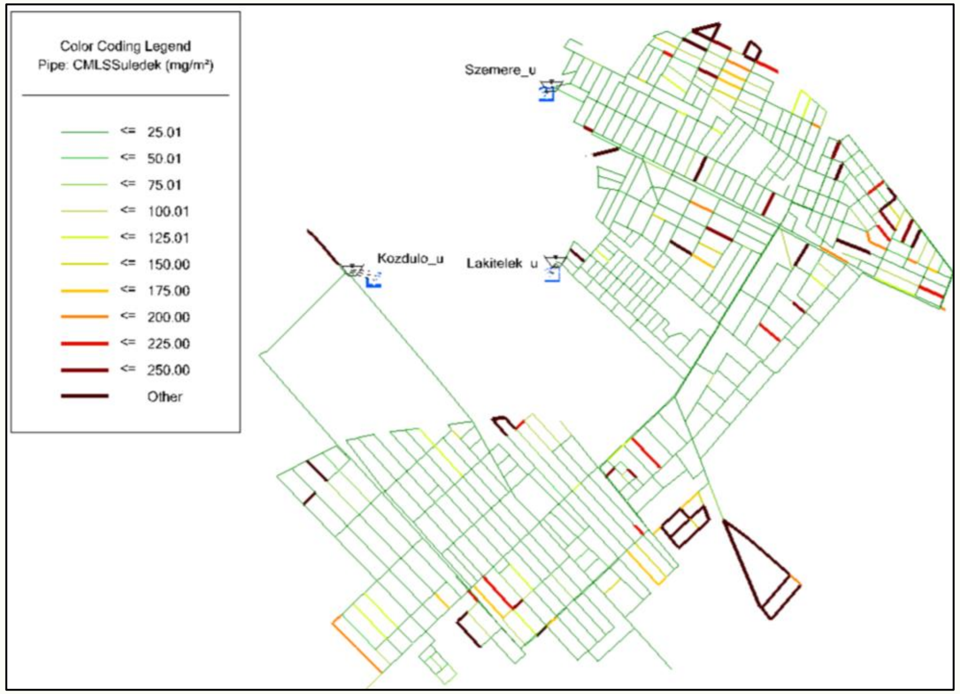
Chlorine decrease equations in the model describing the effect of the sediment

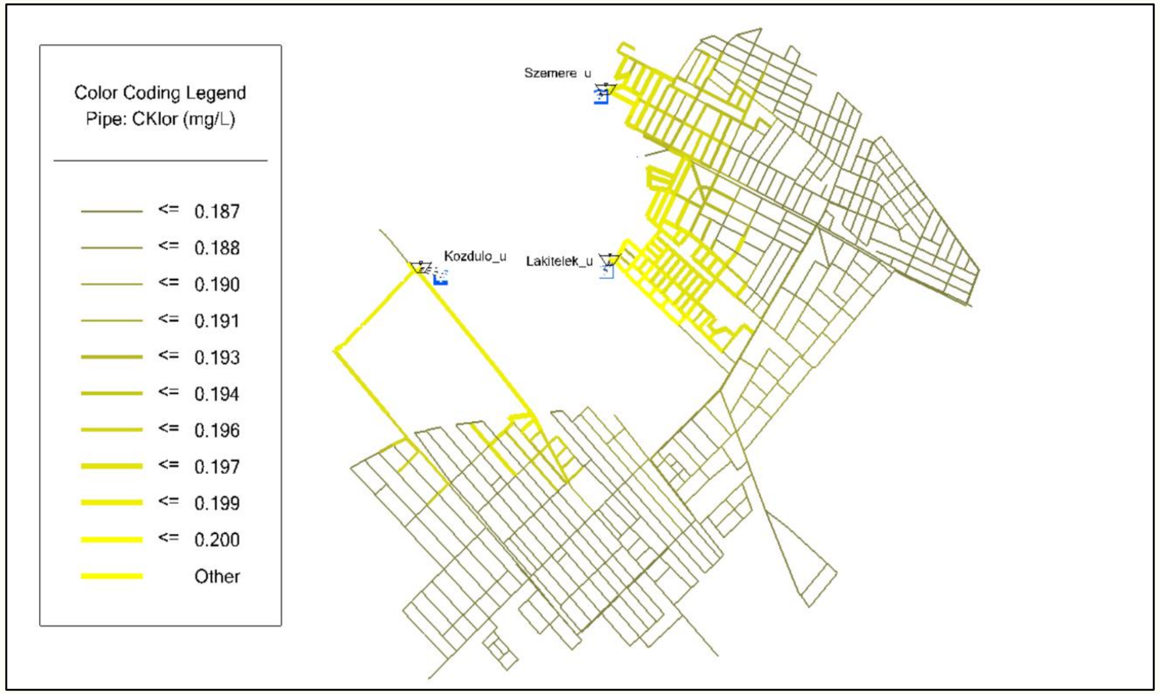
$$\frac{\partial Cl}{dt}\,[\text{hours}] = \min\left(-0.005 * C_{inert};\ \sqrt[3]{\frac{C(MLSS_{sediment})}{36}} * [a_1 + a_{10} * [a_2 * \sqrt{C_{inert}} + a_3 * \text{Cl} + a_4 * (\text{Cl} * a_5 - a_6)^2 + a_7 * e^{(\text{Cl} * \sqrt{C_{inert}} * a_8) + a_9}\right.$$

Parameters in sediment eq.	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
	0,24	1,15	-1,7	-4	-0,8	-0,646	2,8	-5	-0,78	0,6

Test results with the developed model (sedimentation and chlorine decrease)



The amount of sediment deposited on the pipelines per surface area



Chlorine concentration in the pipelines

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