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Long term investigations of the colmation processes at a real sewer defect

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Urban groundwater is prone to quality deterioration due to existing defects in waste and storm water systems where raw sewage water is exfiltrating. It is even uncommon that groundwater in urbanized areas is not affected through marker species originating from the municipal sewage.

The exfiltration process however is strongly influenced by the self-sealing of the defect area through the phenomena of colmation. Colmation is generally described by the reduction of the hydraulic conductivity of a porous media and is caused on the one hand due to the particulate matter in the sewage (i.e. physical colmation) and the microbiological growth of bacteria, fungi and algae in the sewer pipes and in particular in the defect area itself (biological colmation). The effect of colmation and the steering processes have been investigated in the laboratory (slow sand filters, column experiments) as well as on special equipped test sites. Experiments accounting for undisturbed conditions at real sewer defects lacked so far.

For that purpose a special test site was constructed at the outlet of a 60 ha catchment area to perform measurements under operating conditions. An active sewer where mainly domestic sewage is conveyed was cracked to represent real sewer defects. Two artificial leaks (Leak 1: 120 cm^2 and leak 2: 75 cm^2) were milled into a 500 mm sewer. The main focus was put on the quantification of the exfiltration, which was recorded with a high temporal resolution by the installation of a drop counter below leak 1. A second focus was put on the assessment of the spatial distribution of the colmation

layer in the defect itself. The determination of the bacterial biomass indicated the population density (DNA concentration) and the bioactivity (RNA/DNA ratio) and furthermore the spatial occurrence in the horizontal and vertical profile.

During the initial period of the experiment the exfiltration quantity ended at 250 l/d but decreased continuously and reached 2 l/d after a period of 145 days. Fill level variations affected the exfiltration at the beginning of the experiment strongly, and the exfiltration increased by the factor of 20 compared to the dry weather exfiltration, while the storm weather exfiltration was only three times higher after 145 days. The colmation layer seems to be vulnerable against variations of the hydrostatic, pressure, the flow velocity and the towage strain at the base of the sewer. Even tough, once the colmation layer is developed (i.e. app. 7 month) the vulnerability against different boundary conditions decreased significantly. The results are standing in a strong contradiction to laboratory results, where an effective sealing could be observed within days or even hours.

Based on the optical analysis of soil cores with a length of 6,0-9,0 cm, taken in-situ at the defects, the vertical profile have been divided in three horizons, which showed a good accordance to the biomass distribution. The first horizon from 0,0-2,0 cm was of a humus consistence and completely black due sulphide precipitation products. No residues of the bedding material (i.e. middle sand) could be determined. The DNA concentration laid in the first millimetres with 400-570 μg/g three times higher compared to the laboratory results and increased to the maximum concentration of 590-780 μg/g in 1 cm depth. Horizon 2 from 2,0-5,0 cm could be described as a transition zone. The clearly visible grains of the bedding material are part of the soil core, which are only of brownish colour. Most of the heavy metals have been precipitated already in the upper layers. The concentration of biomass dropped down with a steep gradient and reached less than 200 μg/g. The horizon 3 from 5,0 to 9,0 cm consisted completely out of the bedding material showing the typical rose-grey colour.

It is therefore to postulate that the uppermost centimetres of a colmation layer (i.e. 0,0-5,0 cm) in a sewer defect at the base of the pipe are the most effective. However, it can not be differentiated whether physical or biological clogging is dominating. The time period until the system “sewer defect” can be considered as stable, has to be set up to several month instead of days or weeks.