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Management of risk of tree and shrub root intrusion into sewers

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ABSTRACT

The major objective of this study was to determine the frequency of root intrusion into sewers and the sizes of the roots reported. The data were used to develop two methods: one for determining risks related to root intrusions into sewers and sewage flow blockage and the other for establishing the category of probability of root intrusion into sewers with structural defects.

The data on root intrusions into sewers and sewer defects allowing such intrusions were collected through CCTV surveys conducted by the Kielce University of Technology for more than 29 km of concrete and vitrified clay sewers. The frequency of root intrusions into sewers and the sizes of the roots were determined for sewers in Polish cities. The root sizes were classified as one of the five categories of probability of sewage flow blockage, proposed on the basis of the ratio of the cross-sectional area of the roots intruding into a sewer to the total cross-sectional area of the sewer. The study involved proposing a method for determining the category of root intrusion consequences for sewers with roots already growing inside and a method for determining the sewage flow blockage risks related to root intrusion. The latter method can be used to establish the category of root intrusion probability on the basis of structural sewer defects allowing root intrusion as well as factors not related to the sewer, e.g. tree species or the distance of the tree from the sewer.

From the investigations it is evident that root intrusions into sewers are serious problems in Poland and in other countries. The methods proposed in this paper are important tools to be used for proper management of sewer systems.

1. Introduction

As sewers deteriorate with time (Younis and Knight, 2010; Tran et al., 2008), they may contain defects that pose the risk of sewage flow blockage (Veldhuis et al., 2011; Zayed et al., 2011) defined (Rak, 2004) as the product of the probability of the occurrence of sewage flow blockage and its consequences.

Sewer defects can be classified into two main groups: structural (e.g. internal corrosion or longitudinal cracks) and operational (e.g. movable deposits or infiltration of groundwater into a leaky sewer). The latter group also includes root intrusions into sewers.

The consequences of sewage flow blockage depend on the type of sewer. Sanitary sewers are considered to pose the most serious hazards because of the composition of wastewater; the consequences are less serious in the case of combined sewers and the least serious when storm water sewers are involved. Partial or total flow blockages due to root intrusion may result in exfiltration of wastewater through leaky pipes into the surrounding soil and groundwater and, consequently, their contamination (Stein, 1999; Selvakumar et al., 2004). Sewer overflows may lead to flooding and pollution of the neighbourhood (Hammond et al., 2015). The blockages attributable to root intrusions are estimated to represent about 50% of the total number of sewer blockages (Randrup et al., 2001). These findings are confirmed by the results of the surveys conducted in Poland (Kuliczkowska, 2008), with the data obtained being as follows: vitrified clay sanitary sewers – 65.1%, concrete sanitary sewers – 50.1%, concrete combined sewers – 52.5% and concrete storm water sewers – 77.6%.

Surveys of root intrusions into sewers have been conducted in many countries. Östberg et al. (2012) examined a total length of 33.7 km of sewers in two Swedish cities, Malmö and Skövde, and detected 2180 points of root intrusion; this suggests that the frequency of root intrusion into sewers is 6.47/100 m. The surveys, which aimed at determining the influence of the frequency of root intrusions (reporting 14,552 woody plants growing close

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to sewers), revealed that the two species responsible for the most frequent root intrusions into sewers were *Malus floribunda* Siebold ex Van Houtte with 0.694 intrusions per joint and *Populus canadensis 'Robusta'* Moench with 0.456 intrusions per joint. There are large discrepancies between the types of roots entering sewers observed during surveys conducted by other researchers in other cities, countries or continents. In Germany, for example, (Bosseler et al., 2001), the most problematic species of trees are *Acer platanoides* L., *Acer saccharinum* L. or other *Acers* (43% of all intrusions) and *Platanus acerifolia* (Aiton) Willd. with *Platanus hispanica* Münchh. (34%). In Australia, however, root intrusion problems are mainly due to *Eucalypthus* L'Hérit. and *Melaleuca* L. (Pohls et al., 2004).

Root intrusions into sewers are generally associated with sewer defects; they may, however, be attributable to factors not related to sewers. Bosseler et al. (2001) indicate that, apart from the species and sizes of trees, the most important factors are: the type of soil (with the largest number of root intrusions being observed in silty soils and fine sandy soils, constituting 50% of the soil types analysed), the sewer burial depth (with most root intrusions reported for sewers laid at a depth of 2–3 m, which constituted 86% of the analysed depths from the range 0–6 m), the water table level (with most root intrusions observed for the water table level at a depth of 5–10 m (27%), 3–5 m (21%) and 1.5–3.0 m (20%)) and the distance between the tree and the sewer (with the percentage of root intrusions being 34% at a distance of 0–1 m, 24% at l = 1–2 m, 27% at l = 2–3 m, 12% at l = 3–4 m and 3% at l = 4–5 m). The above results suggest that the risk of root intrusion into a sewer can be reduced by planting the right tree and shrub species at the largest possible distance from the sewer. The other factors not related to sewers, i.e. type of soil, water table level and sewer burial depth, are fixed and cannot be changed.

A quantitative analysis of the frequency of root intrusions, similar to that conducted by Östberg et al. (2012), was carried out in Poland by the Kielce University of Technology for a similar length of sewers (29,013 m) using CCTV (closed-circuit television) equipment. The novelty of the Polish investigation was that root intrusion cases were categorised using the ratio of the cross-sectional area taken up by the roots intruding into the sewer to the cross-sectional area of the whole sewer as the main criterion. Five categories of probability of sewage flow blockage caused by root intrusion were established. The categorisation criteria were set on the basis of the survey results obtained by Kuliczkowska (2015) and by analysing the classifications of defects proposed by the water authorities in Germany (ATV-DVWG-A149, 1994; ATV-DVWG-M149, 1998), Holland (Stichting Rioned, 1998), the United Kingdom (Water Authorities Association, 1990), and the United States (NASSCO, 2015) and by the Danish company Per Aarsleff A/S (Per Aarsleff, 1989).

The studies also involved categorising the consequences of sewage flow blockage caused by root intrusion into a sewer based on 11 factors.

Östberg et al. (2012), who investigated the root intrusion phenomenon associated with different trees and shrubs, report that:

- many questions on the causes of root intrusion into sewer pipes still remain to be answered,
- further research is required to make solid recommendations on tree and shrub species to reduce the risk of root intrusion.

This study had three objectives. Firstly, it was vital to continue the research initiated by Östberg et al. (2012) but this time the research efforts focused on determining the frequency of root intrusion into sewers in Poland and the sizes of roots. Secondly, it was essential to indicate the sewer defects (excluding leaky pipe joints) that facilitate root intrusion and factors unrelated to sewers but contributing to root intrusions. Finally, the study proposed an effective strategy for management of risk in the case of root-intruded sewer pipes. The strategy is designed to completely eliminate or significantly reduce the risk of root intrusion into sewers, and consequently, reduce the risk of sewage flow blockage.

2. Methods and materials

This paper summarizes the results obtained from investigations of the root intrusion phenomenon, which affected pipes with a long service life made of vitrified clay and concrete. The investigations were performed between 1991 and 2015 using the CCTV method. The analysis concerning vitrified clay pipes was based on the data from 66 surveys carried out on 422 sewer sections in 19 Polish cities and towns:

- Bochnia,
- Brwinów,
- Cieszyn,
- Giżycko,
- Kazimierz Dolny,
- Kielce,
- Konin,
- Olsztyn,
- Ostrowiec Świętokrzyski,
- Piotrków Trybunalski,
- Radom,
- Siedlce,
- Tarnów,
- Tomaszów Lubelski,
- Włoszczowa,
- Wrocław,
- Zagnańsk,
- Złotów,
- Zwierzyniec.

The investigations covered 14,897 m of randomly selected vitrified clay sanitary sewers, diverse in terms of the town, street and pipe diameter. The vitrified clay sewer pipes varied in diameter from 200 mm to 500 mm. The surveys regarding concrete pipes were conducted in 23 Polish cities and towns:

- Baranów Sandomierski,
- Bochnia,
- Brzesko,
- Chmielnik,
- Dębica,
- Garwolin,
- Kielce,
- Konin,
- Kutno,
- Mielec,
- Nisko,
- Nowy Sącz,
- Oborniki Wielkopolskie,
- Połaniec,
- Pułtusk,
- Pustków,
- Rzeszów,
- Tarnów,
- Tomaszów Lubelski,
- Włocławek,
- Włoszczowa,
- Zakliczyn,
- Zelów.