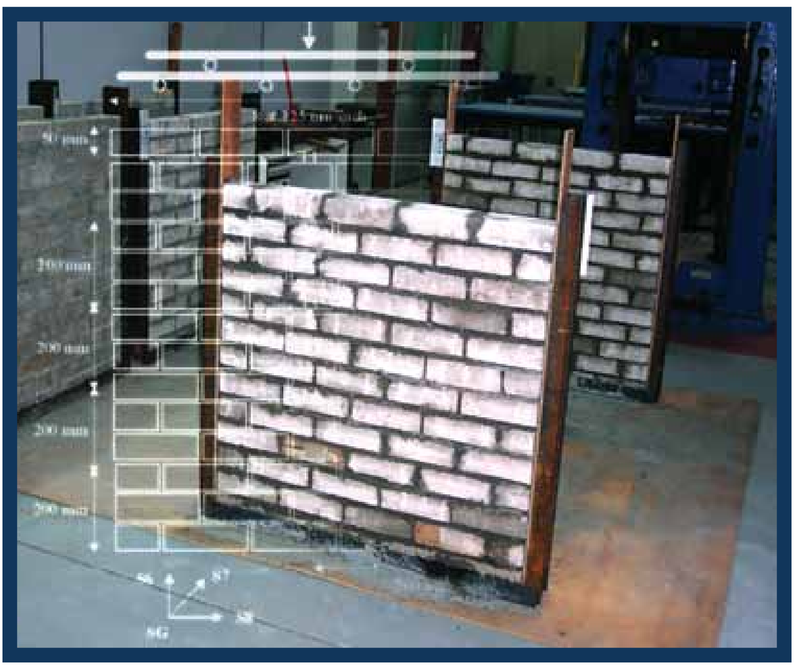
Volume 3 No. 2
Dec 2006

ISSN 1675-7009

Scientific Research Journal



Institute of Research, Development and Commercialisation

SCIENTIFIC RESEARCH JOURNAL

Scientific Research Journal is jointly published by Institute of Research, Development and Commercialisation (IRDC) and University Publication Centre (UPENA), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

SCIENTIFIC RESEARCH JOURNAL

Vol. 3 No. 2 December 2006 ISSN 1675-7009

Scientific Research Journal *Vol. 3 No. 2, 61-69, 2006*

Exfiltration from Sewers: Effects of Different Types of Leakage

Mohd Ashaari Ab Wahab, Suhaimi Abdul Talib, Bahardin Baharom & Mat Som Marwi

Institute for Infrastructure Engineering and Sustainable Management (IIESM)
Faculty of Civil Engineering
Universiti Teknologi MARA (UiTM), Malaysia

ABSTRACT

This research was conducted to study exfiltration of wastewater from gravity sewers. Exfiltration through different types of sewer leaks were studied. With the different size of leakage areas and a constant thickness of soil bedding, it was found that the exfiltration rate reduces and became constant over a duration of one (1) to three (3) days. Knowing the exfiltration rate, the time taken for the polluted water exfiltrate from sewer pipes to reach the groundwater can be determined so that preventive measures can be taken to prevent it. From studies conducted, it can be shown that the size of the leakage area was found to play an important role in determining the size of the clogging zone, the increased in the clogging zone resulted in the decreased of exfiltration rate due to the accumulation of organic matters at the edge of the leakage area and trapped in the pores of the bedding soil

***Keywords**: Exfiltration, wastewater, gravity sewers, sewer leaks, clogging zone*

Introduction

Sewerage system plays an important role in ensuring public health, environmental protection and enhancing the standard of living of the general population. Sanitary sewer systems are designed to collect and transport

ISSN 1675-7009

to waste water treatment facilities the municipal and industrial waste waters from residences, commercial buildings, industrial plants, and institutions, together with minor or insignificant quantities of ground water, storm water and surface waters that inadvertently enter the system [1].

Broken sewer and leakage pipes have been identified as one of the major problems in sewer network management. Serious environment damage and threats to the local community may result from sewage being release into the soil and groundwater. This project is intended to provide a clear understanding on the exfiltration behaviour so that corrective and preventive measures can be recommended and implemented.

Vollertsen and Hvitved-Jacobsen [2] conducted pilot scale experiments on exfiltration of wastewater from gravity sewers. The effect of storm events, flushing of pipes and alternating infiltration or exfiltration were simulated in the experiments. Exfiltration through different types of sewer leaks and into different soil beddings condition were also studied. That mean, it can be estimate how long the exfiltration will polluted the groundwater. The exfiltration was governed by the development of a clogging zone at the sewer leak and could be characterized by a leakage factor. The leakage factor may then be use to estimate the risk of groundwater pollution from a sewer network. However, it is reasonable to assume that when groundwater can infiltrate, wastewater may also exfiltrate under given conditions.

On the use of TV-inspection for evaluating pollution due to leakages from sewers, available literature agree that the method is inconclusive when identifying if – and to what degree – wastewater leaking is from sewers [3, 4]. In other words, not all damages of sewers are also leaks from exfiltration. The goodness of this postulate is difficult to assess as a missing correlation between the damages found by TV inspection and exfiltration could also be due to difficulties in determination of exfiltration [5].

The main objective of this study is to establish of an experimental procedures for determining exfiltration from sewers due to different leakage causes under various flow and to determine exfiltration from sewers due to different sizes and faulty sewer fittings under various flow and soil bedding conditions.

Experimental Set-up

Figure 1 shows the layout plan for the equipment used for the study of exfiltration from various pipes. The equipment was set-up near an operational aeration settling tank at Univesiti Teknologi MARA main campus in Shah Alam. This circular aeration tank has a capacity to process wastewater produced by approximately 3000 residence and non-residence populations. A supply of fresh wastewater from inlet of the aeration tank was pumped into a 150-gallon tank as shown in Figure 1. The wastewater was allowed to flow into a 100-gallon tank before it flows under gravity, through four sets of 110mm PVC pipes placed at a gradient of between 1.0 to 1.5 %. The flow rate of 0.3 m/s were maintained by controlling the inlet valves.

Four 300 mm diameter by 750 mm height column reactors (marked A, B, C and D in Figure 1) were placed under the pipes. Figure 2 and Figure 3 show the cross-sections of one of the column reactor. A stainless steel net with 1 mm openings was placed at the bottom of the column and two layers of soil were laid on top of it consisting of a layer of gravel underneath a layer of sand. The gravel was used to support and control the thickness of the sand bedding and performed as an underdrain. Different height of sand bedding can be simulated by varying the thickness of the gravel and sand layers.

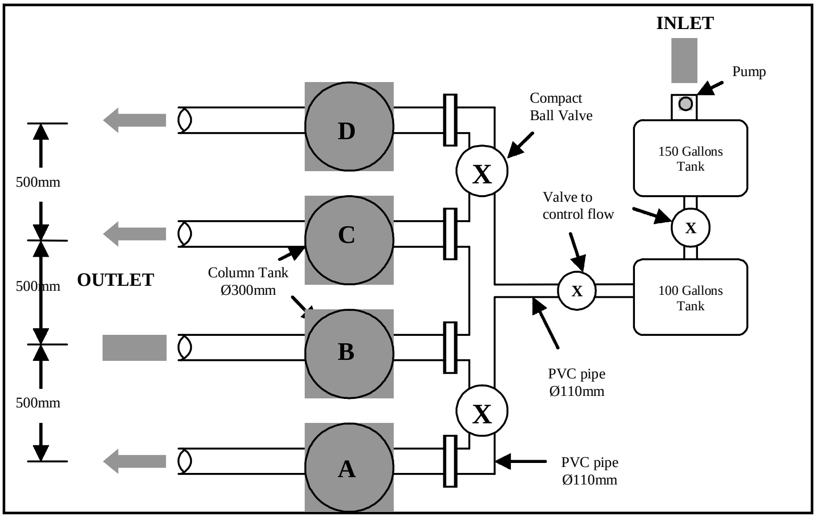


Figure 1 : Experimental Set-up for Exfiltration Experiment

Experimental Works

During the experiments, all the PVC pipes and the column reactors described above were used. A hole is made underneath each pipe above the reactor. Different size of hole is made in each pipe to simulate the different sizes of leakage. In this study, three different sizes of leakage and faulty fitting (Figure 2) were used. The three different sizes of leakages are 10 cm^2, 20 cm^2 and 30 cm^2. Sand bedding thicknesses of 200 mm and 300 mm were used in the experiments.

Wasterwater was allowed to flow through each of the PVC pipes at a constant rate of 0.15 ms^{-1} and 0.3 ms^{-1}. The excess wastewater was collected and discharged back into the aeration tank at the outlet. Exfiltration from the leak in the pipe was allowed to flow through the sand bedding an into the free-draining gravel layer. A funnel underneath a column reactor then channeled the exfiltrated water into a measuring cylinder. The volume of water collected in the measuring cylinder was recorded with time. The exfiltration rate through the soil bedding were measured for several days until the exfiltration rate became constant.

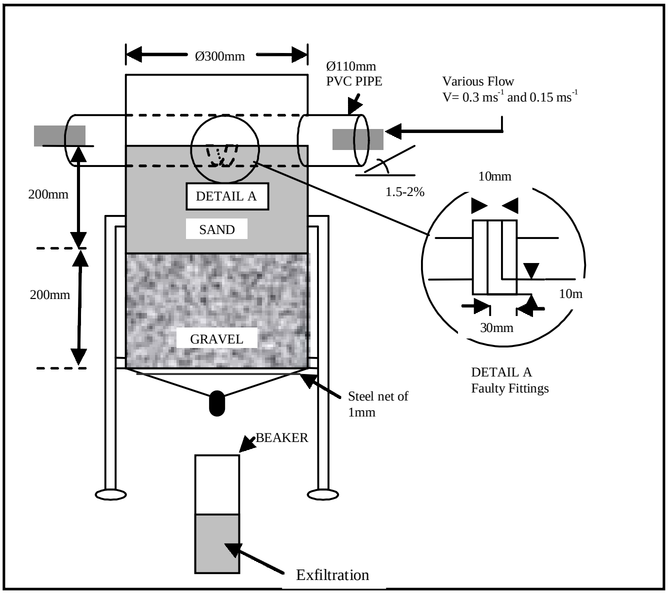


Figure 2: Faulty Sewer Fittings and Column Cross Section

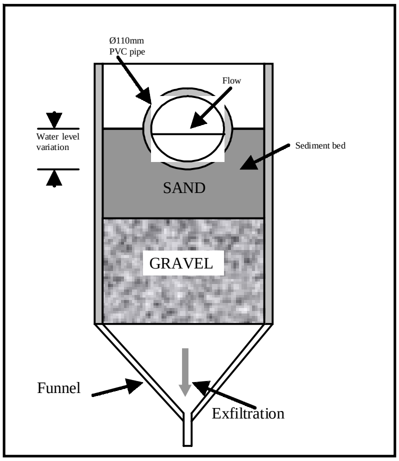


Figure 3: Wastewater Flow Variations

Results and Discussion

Effect of Leakage Areas on Exfiltration Rate

Figure 4 and Figure 5 show the results of test carried out to determine the effect of different areas of leakage on exfiltration. The bedding thickness and flow velocity adopted during these tests were 200 mm and 0.15 ms^{-1} respectively.

It is clearly evident that exfiltration from sewers can be described as a three stage phenomena. The first stage which lasted over duration of 12 hours is characterized by a high and rapidly decreasing rate of exfiltration. The exfiltration rates for the 10 cm^2, 20 cm^2 and 30 cm^2 leakage areas were observed to have been reduced during this stage by 52 %, 68 % and 71 % respectively. This stage is the followed by a further decreasing exfiltration rate over time. This decrease however is much smaller compared to Stage I. By the end of stage II the exfiltration rate observed were between 15 % and 25 % of the initial exfiltration rate. Finally during stage III, exfiltration rate became stable and measured exfiltration rates were 15 %-20 % of the initial exfiltration rates.

Different leakage areas affect only the initial amount of wastewater exfiltrating from the sewer pipe. The large area of leakage tends to release more wastewater into the soil bedding during stage I. However,

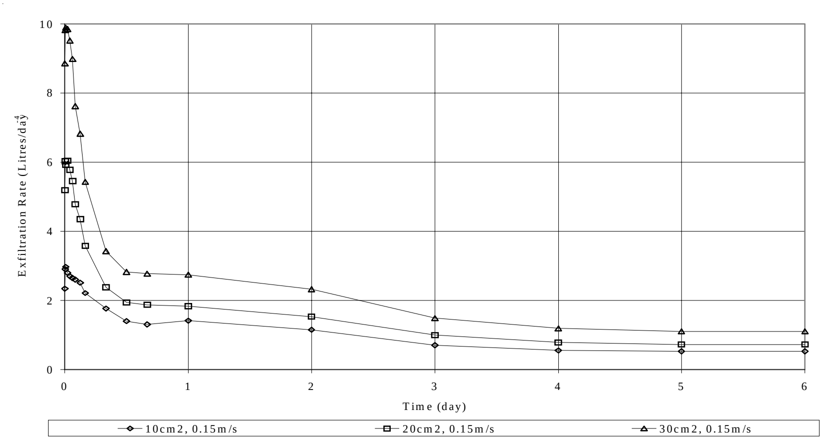


Figure 4: Results of Tests Showing the Effects of Different Leakage Areas on Exfiltration Rate

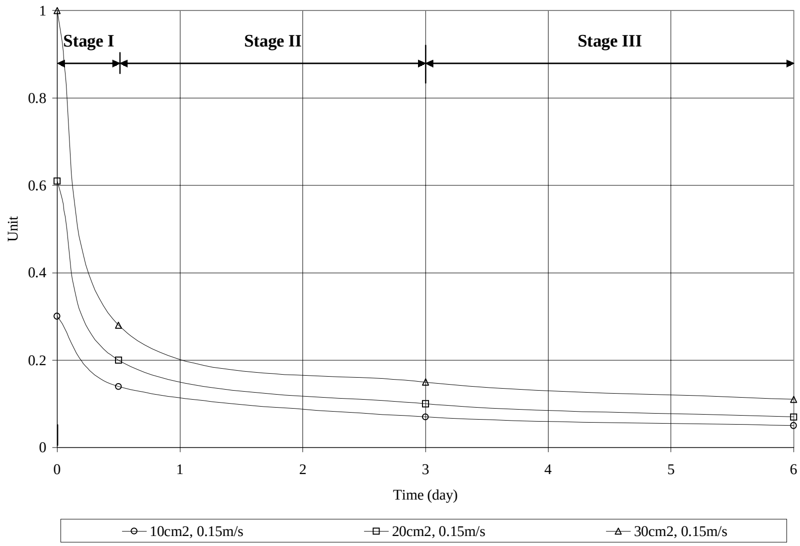


Figure 5: Idealised Results of Tests Showing the Effects of Different Leakage Areas

irrespective of the sizes of the leakage areas the long term exfiltration rates were similar. Thus is can be concluded that, leakage areas do not have a significant effect on exfiltration rates. This can be attributed to the fact that solid in the wastewater filled up the pores in the bedding material, thus making it less and less permeable over time. The behaviour can also be described as a "self sealing" leak.

In these tests, the three stage exfiltration phenomena prevailed. Furthermore it was also observed that the duration of Stage I lasted for 12 hours. The results of these tests are as expected, *i.e.* thicker bedding would result in lower exfiltration rates. This is due to the increase in the flow path and increase in flow resistance, thus reducing the hydraulic gradient required to drive the flow. During stage I, a reduction of 69 % and 60 % of the exfiltration rates were observed for the 200 mm and 300 mm thickness soil bedding respectively. After 6 days the exfiltration the 200 mm thick bedding was measured to be 12 % of the initial exfiltration rate, while in the 300 mm thick bedding, the exfiltration was virtually sealed.

Effect of Faulty Fittings on Exfiltration Rate

Tests were also performed on a faulty pipe joint to determine the effects of flow velocity and bedding thickness on exfiltration from sewers. Results on effects of flow velocity and bedding thickness are shown in Figure 6 and Figure 7.

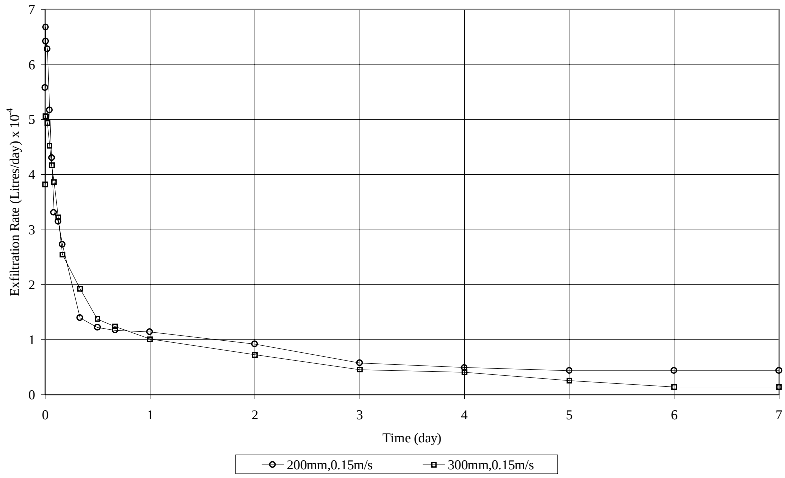


Figure 6: Results of Tests Showing the Effects of Flow Velocity on Exfiltration Rate

In both sets of tests, the three stage exfiltration behavior is clearly distinct. As with the case of holes of different sizes, stage I of exfiltration from a faulty fitting also lasted for a duration of 12 hours. The results obtained from these two sets of tests seemed to suggest that both flow velocity and bedding thickness do not have much influence on the exfiltration rates from sewer pipes.

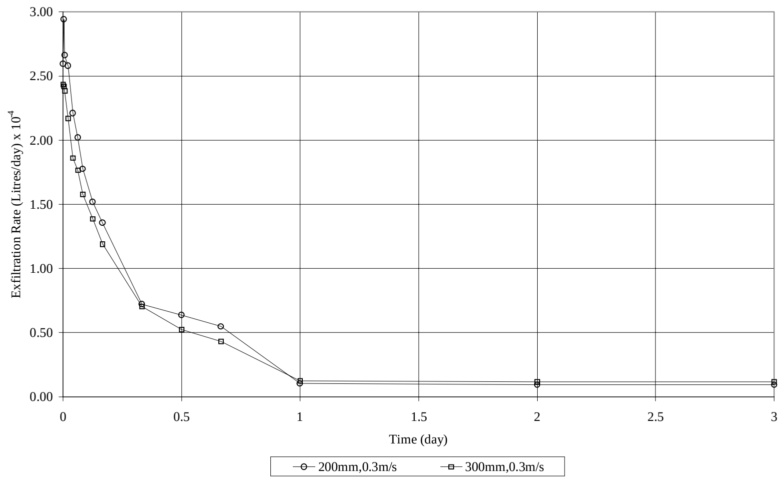


Figure 7: Results of Tests Showing the Effects of Bedding Thickness on Exfiltration Rate

Conclusion

From the results, the following conclusion can be drawn.

1. The apparatus and experimental set-up designed in this study has successfully enabled the exfiltration rates from sewer pipes to be determined.
2. Overall findings of this project had shown that irrespective of the study condition, the exfiltration rate behaviour can be described by a 3-stage process. Stage I involves a rapid decrease in exfiltration rate. This stage lasted over duration of 12-24 hours. Stage II is followed by a further reduction in exfiltration rate. However the reduction in this stage (Stage II) is very much lower compared to Stage I. Finally during Stage III the exfiltration rate becomes constant and it is less than 10 % of the initial exfiltration rate.

3. This study shows that the size of leakage affects only the amount of exfiltration. A large leakage area leads to high amounts of exfiltration. However if rates and flux are considered, leakage areas do not have much effect on the exfiltration rates. Exfiltration rate becomes constant after 3 days.
4. Further studies should be conducted to determine the effect of different grading (of bedding material) on exfiltration rates and also on the wastewater quality exfiltrated from sewers.

References

[1] Amick, R. S. and Burgess, E. 2000. Exfiltration in Sewer Systems. *National Risk Management Research Laboratory*, 26.

[2] Vollertsen, J. and Hvitved-Jacobsen, T. 2002. Exfiltration from gravity sewers – a pilot scale study. *3rd Int. Conf. on sewer processes and networks*, Paris, France, pp. 155-162.

[3] Eiswirth, M. and Hotzl, H. 1994. *Groundwater contamination by leaking sewerage systems*. Water Down Under, November 1994, Adelaide, Australia, pp. 21-25.

[4] Knudsen, L., Andersen, U., Orskov, P. and Pederesen, C. M. 1996. Avoid drinking water pollution. *Stands og havneingenioren*, 10, pp. 34-36.

[5] Ab-Wahab, M. A., Abdul-Talib, S., Baharom, B. and Marwi, M. S. 2004. Exfiltration from sewers pipes – Effects of flow rates, different leakage area and soil bedding. *1st Asian Junior Scientists Workshop on Sewer Network Processes and Urban Drainage,* Faculty of Civil Engineering, UiTM, February 7-10, Malacca, Malaysia.