SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 / https://doi.org/10.14445/23488352/IJCE-V9I1P102

Volume 9 Issue 1, 7-14, January 2022
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Original Article

Underground Pipeline Leakage Risk Evaluation in Ajdabiya City, Libya

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Received: 11 December 2021 Revised: 12 January 2022 Accepted: 25 January 2022 Published: 31 January 2022

Abstract *- Leak detection in transmission pipelines is crucially important for safe operation. Delay in detecting leaks leads to loss of property, roads and infrastructures. This research work is aimed to detect the leaks and evaluate their causes and effects. the results show that the leakages caused by; networks are small size pipes with high pressure, corrosion, damaged pipe joints, the rising water level in the city and tree roots. the ground subsidence and sinkholes spread in several streets in the city are the most common way to identify the leaks in the water and sewer networks. Pipeline leakage has both economic and environmental effects where the leaks cause many problems such as; health hazards a result of mixed groundwater with leaked wastewater. Loss of drinking water, soil erosion and ground subsidence. Also, leakages involve a significant economic loss reached 2 million Libyan dinars in the last 10 years. Most water and wastewater pipes are buried underground, making them difficult to find the location of leaks. So, using smart technologies such as; ground-penetrating radar, Acoustic systems, Sensor hoses, Fiber Optic Cable.. etc., are important to detect the leakages in the early stage.*

Keywords *- Leakage, Water and Sewer System, Pollution, Ground Subsidence.*

1. Introduction

Underground pipeline systems such as water and sewer networks are vital infrastructures that cities and societies greatly depend on, yet they are often also the oldest. the pipes are made from different materials, which have different deterioration mechanisms, significantly increasing the challenges for condition assessment. Also, they are buried, which makes their condition assessment extremely complex and challenging.[1]

Underground pipeline safety is a concern among civilians in populated urban cities. Due to the potential for considerable damage from underground pipeline leakages, it is critical to identify potential risk areas.[2] Where the underground leakages in the Sewer and water pipelines have become a critical issue in most countries worldwide.[3]

The leakages of water and wastewater from water and sewer systems in urban areas cause several problems such as deficiency of drinking water, groundwater contamination, deterioration of soil, and ground subsidence. in the city of Ajdabiya, sewer and water networks deterioration and the associated problems of water and wastewater leakages have become more and more prominent within the last decades (Fig, 1).

Most of the water and wastewater pipes are buried underground, making them difficult to find the location of leaks. for this reason, water leakage has usually been detected when it flows out of the ground due to massive leaks in pipes. the main goal of this paper is the evaluation of exfiltration effects from leaky water and sewer pipes.

2. Objectives

The main objectives of this paper are:

- To locate the position of the leakage that occurs in the pipeline.
- Determine the main causes of leakages.
- Establish the effects of leakages.
- Give the ways to discover the problems.
- Recommended the best technologies used o detect leakages.

3. Methodology

The study relied on the following steps:

- Collecting data and information from references, practical papers, and the Internet.
- Field visits to locate leaks and ground subsidence and determine their causes.
- Obtaining information from the General Company for Water and Sanitation and following up on some maintenance works for some roads in the city.

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Fig. 1 Close-up of ruptured sewer rusty pipeline which causes sewage leakage stream and pollution. Old infrastructure issues in the city (Tripoli Street).

4. Results and Discussion

4.1. Causes of Pipelines Leakages

Many factors are involved in the leakage detection of the water and sewer in the networks (Fig, 2). the main parameters considered for leakage are presented in Table 1. Below, we'll discuss a few of the most common leaks in Ajdabiya City:

4.1.1. The Age and type the Pipes

The age of pipes has a direct or indirect effect on the amount of leakage. So a program can be planned with a timetable for the efficiency and rebuilding of the pipes with different qualities so that the loss of water will decrease.[12]

The 70 % of pipe type in the Ajdabiya city is Asbestos-cement (AC) pipe. the AC pipe lifespan at 70 years, but actual service life depends largely on pipe condition and working environment.[12] So, the pipe age is not the cause of leakages in the city, but bad use of the network and the entry of chemicals into the network led to a significant deterioration of the network and thus shortened the life of the pipes.

4.1.2. Pressure

The high pressure causes the increase of leaks and the loss of consuming water and the number of accidents in the network.[4] According to the previous studies (Table 1), the main reason for leakages is pressure. If your water or wastewater pressures are excessively high, it could cause your pipes to leak and even burst. When the pressure in your pipes is distributed unevenly, it puts unnecessary force on the rest of your pipes and causes leaks.

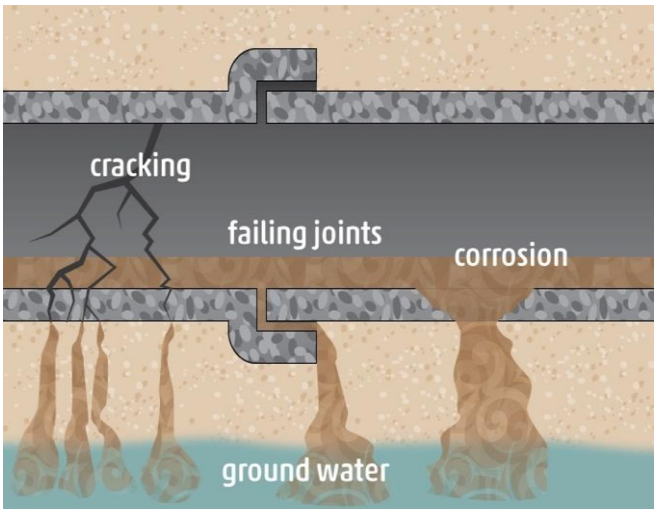

Fig. 2 The main reasons for pipe leaks. [13]

Table 1. Main parameters considered for leakage.

References	Main pipe parameters considered in causing leakage
Saghi and Aval [4]	Pressure, age, material and diameter of the pipe
Jing and Zhi-Hong [5]	Material, age, pressure, diameter, the depth of the placement of the pipe
Li et al. [6]	Material, age, pressure, diameter
Perez et al. [7]	Pressure
Marunga et al. [8]	Pressure
Nicolini et al. [9]	Pressure
Berardi et al. [10]	Age, diameter, length
Araujo et al. [11]	Pressure

The size of the pipes used in Ajdabiya city is 200 mm (8 inches). the network was designed 40 years ago for a population between 60 and 70 thousand. the work began in 1982, and the project was delivered in approximately 1989. Currently, the sewage network suffers from high pressure. This is due to the threefold increase in the population of the city, according to the last statistic, which caused an increase in pressure on the network and thus the leakages increased.

4.1.3. Corrosion

Corrosion in your pipes is oftentimes caused by the pH of your water. If the pH is too low, it damages the protective layer inside the pipe and causes it to corrode. When there is too much oxygen in the water, it gradually turns metal pipes to rust. Minerals in the water also speed up the corrosion process.

Over time, AC pipe undergoes gradual degradation in the form of corrosion (i.e., internal calcium leaching due to conveyed water and/or external leaching due to groundwater). Such leaching leads to a reduction in effective cross-section, which results in pipe softening and loss of mechanical strength. [13]

Fig. 3 Corrosion pipe in the city

4.1.4. Damaged Pipe Joints

Pipe joints are the parts that connect your pipes together. Being the weakest point of a pipeline, joints are known to deteriorate and eventually leak over time. Illegal connections on the main network in the city of Ajdabiya in recent years have led to many leaks on the main network lines (Fig, 4).

Fig. 4 Illegal connections on the main network in the city of Ajdabiya.

4.1.5. Rising Water Level in the City

The rise in groundwater in the city leads to a change in the moisture of the layers and the underlying soil, which will lead to the disruption of the water and sewage networks, and thus to the deterioration and cracking of pipes and lead to the leakage of drinking water and sewage. [15]-[16]

Also, the rising in groundwater leads to the corrosion of sewage pipes made of asbestos material. Also, the groundwater represents an obstacle to repairing leaks in the network (Fig, 5).

Fig. 5 Rising water table during maintenance operations.

4.1.6. Tree Roots

Tiny cracks in pipes can release water vapour into the surrounding soil, where tree roots will take notice and burrow their way to your pipes, causing big problems.

Fig. 6 Root trees and their effects on sewer network. 4.2 Effects of Underground Pipeline Leakage

Leaks out may contaminate ground and surface water and cause a host of other problems, including pipe structure failures due to erosion of soil support and ground subsidence due to erosion of underground soil. Major problems of leakages in the pipeline are related to (Fig, 7):

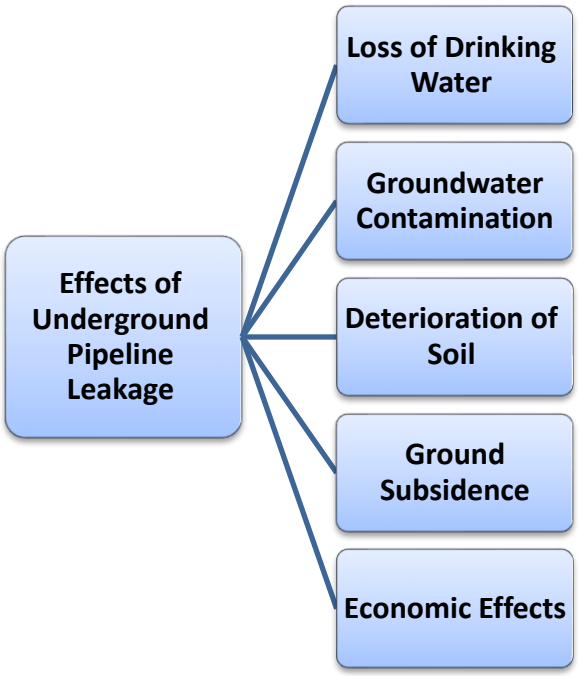

Fig 7. Illustrates the effects of underground pipeline leakage.

4.1.7. Loss of Drinking Water

Water is a precious natural resource to human beings and plants. Unfortunately, a very large amount of water goes wasted as the potential water leaking in most water-distribution systems is getting higher year by year.

Water leaks are not only a waste of precious water resources but also impose danger to roads and infrastructures. the leaks may cause soil erosion or create an underground void that will collapse suddenly when a heavy object passes. the leaks meant the waste of money and created more economic loss to treat and fix the damaged pipe. the below figure shows a water leak in the street, which in turn led to the collapse of the road (Fig, 8).

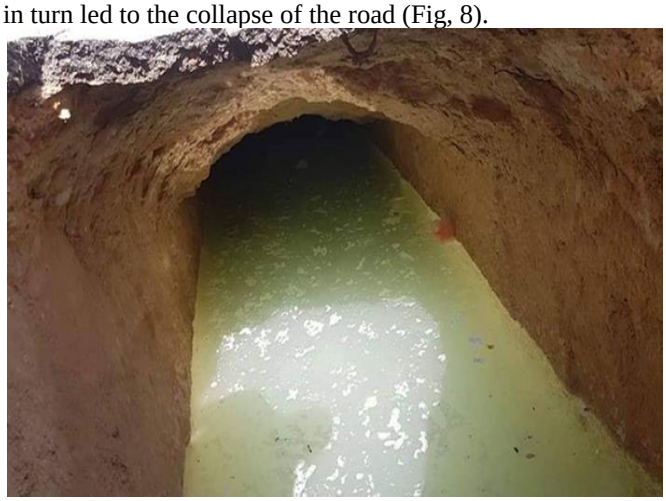

Fig. 8 Water leakage under the asphalt layer.

4.1.8. Groundwater Contamination

Exfiltration is a big problem facing water and wastewater infrastructure. Its effects can harm public health and the environment and necessitate costly repairs. Untreated sewage from exfiltration often contains high levels of suspended solids, pathogenic microorganisms, toxic pollutants, floatables, oxygen-demanding organic compounds, oil and grease, and other pollutants. Exfiltration allows for the release of wastewater without proper treatment.

In the last decade, the city of Ajdabiya has suffered from the phenomenon of rising groundwater, which has become close to the surface of the earth. This rise, along with repeated leakage from sewage networks, led to the pollution of groundwater with sewage water (Fig, 10). the previous studies such as; Emhanna et al., 2021; Emhanna et al., 2020; Shaltami et al., 2020; Al Kassah et al., 2018; Alteera and Ashweshin 2018 and Al Fakhoury and Fayez, A., 2004, confirmed that the groundwater had been polluted by the sewage water. [15]-[16]-[17]-[18]-[19]-[20]

Fig. 9 Groundwater pollution with the sewage water

4.1.9. Soil Erosion

The recurrence of the phenomenon of subsidence or landslide is due to soil erosion over time as a result of leakages from sewage and water pipes in the city streets, causing a disturbance in the surface of the earth that leads to a subsidence of the surface of the earth in a location as a result of changing the properties of the subsoil below this site (Fig, 10).

Fig. 10 Soil erosion due to leaks.

4.1.10. Ground Subsidence

During the past decades, subsidence and sinkholes formed in urban areas are often accompanied by the deterioration of buried pipelines. This type of sinkhole is different from the geologically known and defined sinkholes that can be found in karst formations or that which are formed in limestone. One of the most important mechanisms for the formation of this type of sinkhole is the loss of soil into the sewer pipes through the defects. [21]

Ground subsidence and sinkholes are the most complex civil engineering problems stemming from the interaction of water and the ground. the sinkholes induced by leaking underground pipelines are an important problem that must be extensively investigated. the ground subsidence and landslides spread in several streets in the city (Figs, 11 and 12). They are the most common way to identify leaks in the network.

Commonly used or recommended visual inspections may not be appropriate for this purpose. Visual inspections are expected to be effective if the defects are major or their presence or locations are obvious. Furthermore, if defects are hidden behind the obstruction, they may not be evaluated properly due to accessibility. Also, all defects are not equally important in terms of the structural behaviour in the damaged state.[22]

4.1.11. Economic Effects

According to data from the General Company for Water and Sanitation, the economic losses resulting from leakage problems in the water and sewage networks in the last ten years in the city of Ajdabiya amounted to about 2 million Libyan dinars. [23]

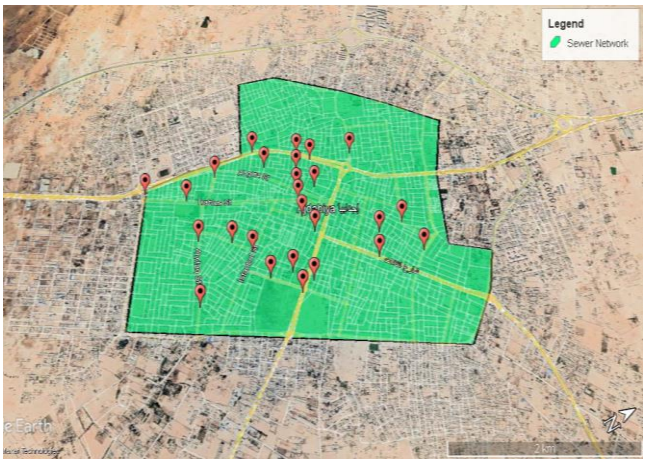

Fig. 11 Subsidence locations in Ajdabiya City.

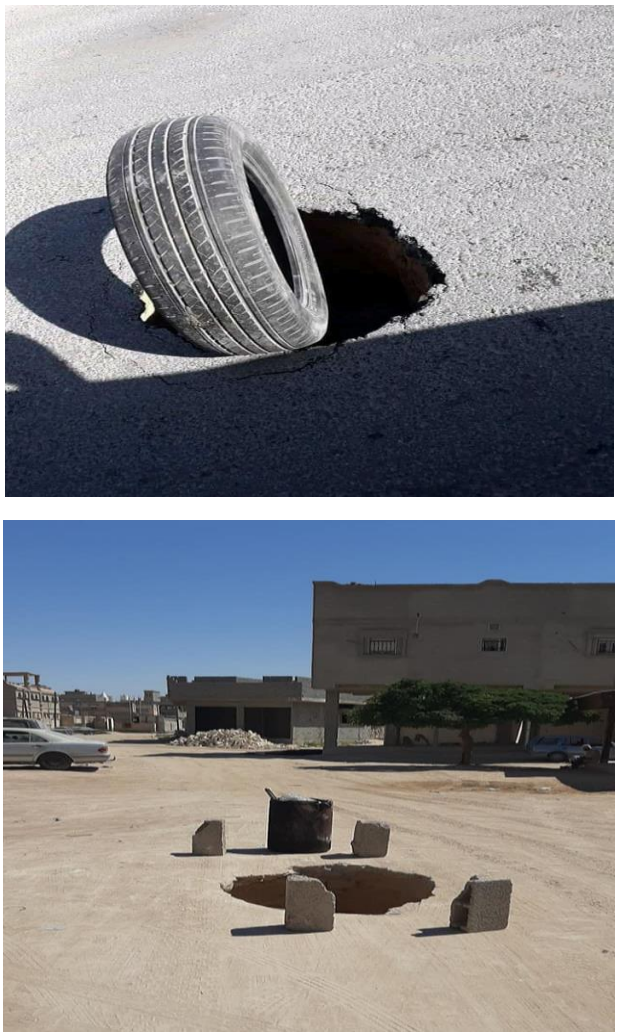

Fig. 12 Pictures of some of the subsidence and sinkholes in the city

5. Conclusion

- Admittedly, most leaking drains and pipes are minor issues when they first start. It is the dangers that build up over time that make them dangerous.
- Based on previous studies, there are many reasons for leakages, but, in the Ajdabiya city, the leakages are caused by the following; small size pipes with high pressure, corrosion in the pipe as a result of bad using and entry chemicals material on the networks, damaged pipe joints and illegal connections on the main network, rising water level in the city and tree roots.
- Pressure and Rising groundwater level are the most important causes of collapses and leaks in the city's water and sewage networks.
- Water and sewage water leaks cause many problems in the sub-ground, whereas leaks in water and wastewater pipelines such as; loss of drinking water, soil erosion and ground subsidence.
- Ground subsidence and sinkholes which spread in several streets in the city are the most common way to identify the leaks in the water and sewer networks.
- the health hazard is another problem as a result of mixed groundwater with leaked wastewater. Also, leakages involve a significant economic loss reached 2 million Libyan dinars in the last 10 years.

6. Recommendations

Because the water and wastewater pipes are buried underground, making them difficult to find the location of leaks. So, using smart technologies such as; ground-penetrating radar, Acoustic systems, Sensor hoses, Fiber Optic Cable.. etc., are important to detect the leakages in the early stage.

References

[1] B. Rajani, and Y. Kleiner., "Non-Destructive Inspection Techniques to Determine Structural Distress Indicators in Water Mains," *Nrc Publications Archive (NPArC)*, pp. 1-20, 2004.

[2] Shing-Yu Chen, et al., "Underground Pipeline Leakage Risk Assessment in an Urban City," *International Journal of Environmental Research and Public Health*, vol. 17. No. 11, pp. 3929, 2020. https://doi.org/10.3390/IJERPH17113929.

[3] T. Karoui, et al., "Experimental Study of Ground Subsidence Mechanism Caused By Sewer Pipe Cracks," *Applied Science*, vol. 8, no. 5, pp. 679, 2018. *Crossref*, https://doi.org/10.3390/app8050679

[4] Hassan Saghi, and Abbas Ansari Aval "Effective Factors in Causing Leakage in Water Supply Systems and Urban Water Distribution Networks," *American Journal of Civil Engineering. Special Issue: Research and Practices of Civil Engineering in Developing Countries*, vol. 3, no. 2-2, pp. 60-63, 2015. *Crossref*, https://doi:10.11648/J.AJCE.S.2015030202.222

[5] Kang Jing ZouZhi-Hong, "Time Prediction Model for Pipeline Leakage Based on Grey Relational Analysis," *Physics Procedia*, vol. 25, pp. 2019-2024, 2012. *Crossref*, https://doi.org/10.1016/j.phpro.2012.03.344

[6] Weifeng Li, "Development of a System for Detection, Early Warning, and Control of Pipeline Leakage in Drinking Water Distribution: A Case Study," Journal of *Environmental Science*, vol. 23, no. 11, pp. 1816-1822, 2011. *Crossref*, https://doi.org/10.1016/S1001-0742(10)60577-3

[7] R. Perez, et al., "Methodology for Leakage Isolation Using Pressure Sensitivity Analysis in Water Distribution Networks," *Control Engineering Practice*, vol. 19, no. 10, pp. 1157-1167, 2011. *Crossref*, https://doi.org/10.1016/j.conengprac.2011.06.004

[8] Antony Marunga, Zvikomborero Hoko, Evans Kaseke, "Pressure Management as a Leakage Reduction and Water Demand Management Tool: the Case of the City of Mutare, Zimbabwe," *Physics and Chemistry of the Earth*, vol. 31, no. 15-16, pp. 763-770, 2006. *Crossref*, https://doi.org/10.1016/j.pce.2006.08.032

[9] Matteo Nicolini, Carlo Giacomello, and Kalyanmoy Deb, "Calibration and Optimal Leakage Management for a Real Water Distribution Network," Journal of *Water Resources Planning and Management*, vol. 137, no. 1, pp. 134-142, 2011. *Crossref*, https://doi.org/10.1061/(ASCE)WR.1943-5452.0000087

[10] L. Berardi, O. Giustolisi, F. Primativo, "Exploiting Multi-Objective Strategies for Optimal Rehabilitation Planning," *Proceedings of Computer and Control in Water Industry (CCWI) - Water Management Challenge Sin Global Changes-Ulaniki*, Taylor and Francis Group, London, pp. 23-30, 2007.

[11] S. Araujo, H. Ramos, and T. Coelho, "Pressure Control for Leakage Minimization in Water Distribution Systems Management," *Water Resources Management*, vol. 20, no. 1, pp. 133-149, 2006. *Crossref*, http://dx.doi.org/10.1007/s11269-006-4635-3

[12] M., Tabesh, and K. Karim, Determination of the Leak Detection and the Renewal Time of Urban Water by Analyzing the Accident Data, vol. 5 , pp. 597 – 610, 2006.

[13] https://www.Exponent.com

[14] https://www.Mswmag.com/

[15] Saleh Emhanna, et al., "Physical and Environmental Effects of Groundwater Table Rising in Ajdabiya Town, Northeast Libya," *Iraqi Geological Journal*, vol.53, no. 2f, pp. 36-48, 2020. *Crossref*, https://doi:10.46717/IGJ.53.2F.3MS-2020-12-26.

[16] Saleh Emhanna, Najeeb Ben Musa, and Mostafa F. Mostafa, "Causes and Impacts of Rising Water Table in Ajdabiya City, Ne Libya," *International Journal of Environment & Water*, vol. 10, no. 2, pp. 127-140, 2021.

[17] Osama Rahil Shaltami, et al., "Assessment of Drinking Water Quality and Sanitation in Ajdabiya City, Ne Libya," *Iraqi Geological Journal*, vol.53, no. 1b, 2020.

[18] S. Al Kassah, et al., "Hydrochemical Study of Some Groundwater Wells in Ajdabiya, Libya," *The Fourth Scientific Conference of Environment and Sustainable Development in the Arid and Semi-Arid Regions (ICESD)*, pp. 839- 856, 2018.

[19] S. Al Teera, and F. Ashweshin, "Environmental Impacts of the Wastewater Treatment Plant in Ajdabiya According to Sustainability Approaches," *The Fourth Scientific Conference of Environment and Sustainable Development in the Arid and Semi-Arid Regions (ICESD)*, pp. 386- 406, 2018.

[20] Al Fakhiry, and A. Fayez, "The Environmental Effects of the Ajdabiya Sewage Station and Sewage Treatment," *Environmental Journal*, pp. 22, 2004.

[21] Mingliang Gao et al., "Regional Land Subsidence Analysis in Eastern Beijing Plain by Insar Time Series and Wavelet Transforms," *Remote Sensing*, vol. 10, no. 3, pp. 365, 2018. *Crossref*, https://doi.org/10.3390/rs10030365

[22] Prof. Shivaji H. Kalyankar et al., "Non_Destructive Testing," *SSRG International Journal of Civil Engineering*, vol. 7, no. 4, pp. 19-21, *Crossref*, 2020. https://doi:10.14445/23488352/IJCE-V7I4P104.

[23] "The General Company for Water and Sanitation," 2022.