International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 01 | Jan 2026 www.irjet.net p-ISSN: 2395-0072

"Geo-tagging and Maintenance Monitoring of Manholes" A Smart Infrastructure Monitoring System for Nagpur Municipal Corporation (NMC)- A Review

Dr. J. S. Gawai[1], Samir Barai[2], Nehali Nanotkar[3], Aishwarya Gajbhiye[4], Gunvant Raut[5], Yugandhar Deshmukh[6]

[1]*Head of Department, Dept of Electronics and Telecommunication, KDK College of Engineering, Maharashtra, India*

[23456]*UG student, Dept of Electronics and Telecommunication, KDK College of Engineering, Maharashtra, India*

Abstract - *Manholes are a very important part of city sewer and drainage systems because they allow workers to inspect, clean, and repair underground pipelines. When manholes are not maintained properly or monitored regularly, many problems can occur such as sewer blockages, water overflow on roads, bad smell, damage to roads, and health risks for people. In many cities, manhole records are still maintained manually, which is slow, inaccurate, and difficult to manage. This paper explains a simple and practical solution using geo-tagging and maintenance monitoring of manholes. Geo-tagging means identifying the exact location of each manhole using GPS technology, while maintenance monitoring involves checking and recording the condition and repair details of manholes. This system helps municipal authorities and workers to easily find manholes, plan inspections, and take quick action during emergencies. By using digital maps and stored data, the system reduces manual work, saves time, and improves decision-making. Overall, geo-tagging and maintenance monitoring help improve sewer management, increase public safety, and support smart city development.*

***Key Words*: Geo-tagging, Manhole Maintenance, GPS, Sewer System, Urban Infrastructure, Monitoring System, Smart City.**

1. INTRODUCTION

Manholes are small but incredibly important parts of any city's sewer and drainage system. They allow maintenance workers to access underground pipelines for cleaning, inspection, and repairs, keeping our cities safe, clean, and functioning smoothly. But as cities grow bigger and more crowded, the number of manholes increases, spreading across roads, footpaths, residential areas, commercial zones, and industrial sites. Managing all of them using traditional, manual methods has become a huge challenge. Often, records of manhole locations, conditions, and past maintenance are incomplete, outdated, or missing entirely. Because of this, authorities can struggle to locate manholes during inspections or emergencies, leading to serious problems like sewer blockages, wastewater overflow, foul smells, road damage, and even health hazards. In many cases, issues are noticed only after damage has already occurred, which is not only costly but also disruptive to daily life.Manual inspection of manholes is also risky. Workers often face dangerous gases, low oxygen levels, and unsafe conditions while entering these underground spaces, which can result in serious injuries or even fatalities. Additionally, relying on paper records or word-of-mouth knowledge makes it hard to keep track of maintenance schedules or prioritize repairs. The whole process is slow, inefficient, and prone to errors.This is where modern solutions like geo-tagging and digital maintenance monitoring come in. Geo-tagging uses GPS technology to record the exact location of every manhole, creating an accurate, easy-to-access digital map. Digital maintenance systems store detailed information about each manhole, including its condition, cleaning history, inspection dates, and any repairs performed. These systems allow authorities to monitor manholes in real-time, plan preventive maintenance, respond quickly to emergencies, and manage resources more effectively.With geo-tagging and digital monitoring, cities can move from a reactive approach—fixing problems only after they occur—to a proactive system, where potential issues are detected early and addressed before they cause damage. This not only keeps the sewer system running smoothly but also protects public health, prevents environmental pollution, reduces repair costs, and makes life safer for maintenance workers. In addition, these technologies support better urban planning, transparency, and accountability, making it easier for municipalities to manage their infrastructure efficiently and sustainably.In short, geo-tagging and maintenance monitoring of manholes is a practical, modern solution for cities struggling to manage their underground sewer networks. By combining accurate location data with real-time monitoring, cities can ensure cleaner streets, safer living conditions, healthier residents, and a more organized and efficient approach to urban maintenance.

2. LITERATURE REVIEW

a) Challenges in Managing manholes using traditional methods present numerous difficulties. In many cities, especially in developing countries, records of manhole locations and conditions are incomplete, outdated, or even nonexistent (Akpan & Agbo, 2018). Field workers often rely

on memory or paper maps, which can be inaccurate. As a result, locating a specific manhole during an emergency can take hours or even days, delaying crucial repairs and risking public safety.Zhang et al. (2019) highlighted that these outdated methods create a reactive maintenance cycle: issues are only addressed after they become serious. For example, sewer blockages are often noticed only when wastewater overflows into streets or homes, causing property damage, traffic disruption, and health risks. Manual inspections are also labor-intensive, expensive, and unsafe, as workers are exposed to hazardous gases and confined spaces. The process is inefficient and increases the likelihood of errors, missed inspections, and delayed maintenance.The consequences of poor manhole management are widespread. Sewer overflows can contaminate soil and water, spread diseases, produce foul odors, and damage roads. Emergency repairs are far more expensive than routine maintenance, creating financial strain on municipalities. Overall, the traditional system is outdated and ill-equipped to handle modern urban demands.

b)Geo‑tagging: Defining and Understanding the ConceptGeo-tagging is the practice of assigning geographic coordinates—latitude and longitude—to a specific location or object. When applied to manholes, geo-tagging allows authorities to mark the exact position of each manhole on digital maps using GPS technology. This makes it easier to locate, inspect, and manage them efficiently.According to Hassan et al. (2020), geo-tagging represents the first step in the digital transformation of sewer infrastructure management. By visualizing the entire network digitally, authorities can better understand the layout, plan inspections, and allocate resources efficiently. Modern approaches go beyond basic coordinates, integrating GIS platforms that store additional data about each manhole—such as age, material type, diameter, condition, and connections to pipelines (Al‑Nabulsi et al., 2021). This layered information gives decision-makers a comprehensive view of the system, enabling informed planning and risk assessment.

c)Digital Maintenance Monitoring Digital maintenance monitoring involves continuously tracking the condition of manholes and sewer lines. Unlike traditional inspections, which may occur sporadically, digital monitoring collects data systematically and in real time.Kumar and Singh (2020) explained that this approach combines geo-tagged data with mobile applications, databases, and dashboards. Field workers can record inspection dates, problems found, maintenance actions, and even photographs of manholes directly through mobile apps. This information is uploaded to a centralized system where managers can analyze trends, schedule preventive maintenance, and generate alerts for upcoming inspections.The major advantage of digital monitoring is that it supports preventive maintenance. By identifying potential problems early, cities can avoid severe blockages, overflows, and costly emergency repairs.

d)Integration of Geo‑tagging and Digital Monitoring Research increasingly emphasizes the integration of geo-tagging and digital maintenance monitoring. When combined, these technologies create a comprehensive system where manholes are accurately located and continuously monitored.Li et al. (2021) developed a digital management platform in which every manhole was geo-tagged and linked to maintenance history, inspection records, and condition reports. The platform automatically generated alerts for upcoming inspections, predicted high-risk locations, and helped officials allocate resources efficiently. Patel and Gupta (2022) also found that integrating geo-tagging with monitoring significantly reduced emergency response times. Accurate location data and real-time status reports enabled teams to reach problem areas quickly, minimizing sewer overflow and property damage.

e)Geo-tagging: A First Step Toward Digital Management Geo-tagging involves marking the exact geographic location of manholes using GPS. Once a manhole is geo-tagged, it can be displayed on digital maps, making it easy for teams to locate and inspect it efficiently.Geo-tagging also allows additional information—like manhole age, material, diameter, and connected pipelines—to be stored alongside location data in GIS systems (Hassan et al., 2020; Al-Nabulsi et al., 2021). This provides city planners with a clear picture of the sewer network and helps in planning inspections, repairs, and resource allocation more effectively.

f)Precise Location Tracking Geo-tagging involves recording the exact coordinates of manholes using GPS devices. This allows maintenance teams to locate access points quickly, saving time and reducing errors. When combined with Geographic Information Systems (GIS), geo-tagging also stores detailed information about each manhole, including material type, age, diameter, condition, and connections to pipelines (Hassan et al., 2020; Al-Nabulsi et al., 2021). This provides managers with a comprehensive view of the network, allowing for better planning, efficient resource allocation, and proactive maintenance. The creation of a digital inventory through geo-tagging also supports historical tracking. Authorities can identify manholes requiring more frequent monitoring, detect early signs of wear, and implement preventive interventions. Studies show that even basic geo-tagging programs significantly improve maintenance efficiency and emergency response.

g)Y. Xie developed a system designed to monitor and secure manhole covers. The system includes four main components: a locked well cover, an alarm terminal, a centralized monitoring server, and a centralized monitoring client. The locked cover and alarm terminal detect any changes in the state of the cover and send this information to the application layer through a network. Once the data reaches the system, the user is notified and can take appropriate action.The application layer, consisting of the centralized

server and client, manages and processes all the information. This system is primarily used by major telecom operators to protect underground cables. It not only safeguards company resources and operations, but also reduces problems caused by faulty or missing manhole covers on roads, helping to prevent accidents and improve public safety.

h)In 2018, W.Z. Black, Robert E. Snodgrass, and Bryan P. Walsh performed a study on explosive incidents caused by explosions inside of electrical vaults and manholes. As part of this study, the authors developed a computer simulation of explosive incidents in both manholes and electrical vaults. The purpose of the computer simulation was to understand how the combination of an electrical fault and an explosion from a manhole gas become a hazardous event. They concluded that there is substantial energy accumulation in a manhole and sufficient pressure build-up to cause the entire manhole cover to "pop" off of the frame. Thus, it was established that manhole covers are susceptible to catastrophic failure, making them a potential threat to public safety. The findings of the computer simulation allowed for the quantification of these effects and recommendations for the design of safety devices that may decrease or eliminate these hazards. In addition to identifying the need for different design approaches for manhole cover restraints due to differing behaviors of the two major types of explosion (chemical and electrical), the authors determined that safety devices must be built to withstand explosive forces and must have rapid response systems that will reduce the internal blast pressure in a timely manner.

3. DISCUSSION AND RESEARCH GAP

Efficient manhole maintenance is a critical aspect of managing water, waste, and utility pipelines in cities and towns. Traditionally, manholes were monitored through manual inspections, paper records, and occasional surveys, which often proved to be time-consuming, costly, and prone to errors. These methods could not keep up with the rapid expansion of cities, increased population, and the growing complexity of underground networks. Over time, this led to several issues, such as unnoticed blockages, overflowing manholes, gas leaks, structural failures, and public safety risks. With the advent of digital technologies, particularly geo-tagging, the management of manholes has become significantly more effective. Geo-tagging allows each manhole to be assigned precise geographical coordinates, making it easier for maintenance teams to locate and inspect them efficiently. When combined with digital monitoring systems, it becomes possible to track the condition of manholes in real time, log inspection reports, monitor gas levels, detect structural anomalies, and even alert authorities or the public about emergencies.

4. PROPOSED METHODOLOGY

The Manhole Maintenance System will use Geo-Tagging Technology for Automation and Improvement.

The first step in the process will involve collecting images of the manholes at the time of inspection. These images shall be collected with a camera (fixed or handheld) and will be Geo-Tagged with a Point of Reference (GPS Coordinates) as well as the Date/Time collected.

This will provide an accurate way of identifying each manhole's unique position and will allow easy tracking of where images were taken. When images and GPS coordinates are collected, they will be uploaded to a secure 3rd Party Internet-Based Storage (Cloud) and accessible by all statutory municipalities for secure data management and storage (scalable). Once the images and coordinates are uploaded to the cloud, they will be pre-processed by using Image Preprocessing Techniques including but not limited to Noise Reduction, Resize, Contrast Enhancement, and Normalization, to improve the clarity and consistency of the image prior to it being analyzed by the Convolutional Neural Network (CNN).

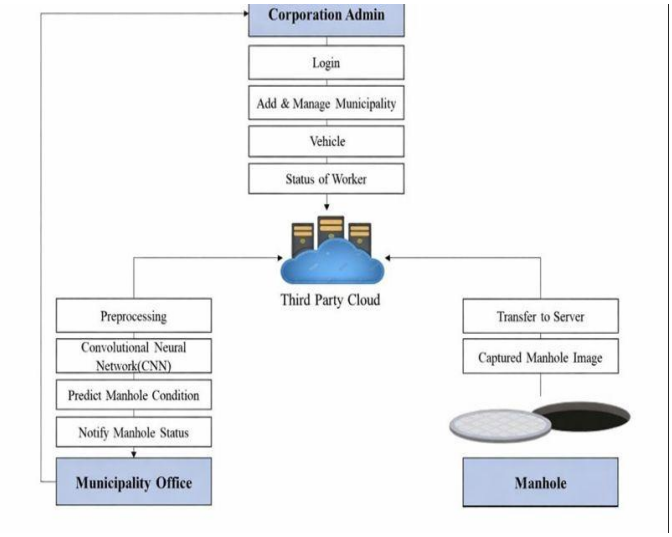

Fig-1: Architecture diagram

The CNN will be trained to extract important visual features from the pre-processed images and classify the Condition of the manhole into Safe, Damaged, Open, Blocked, and Hazardous conditions.

The output from the CNN Model will allow the Automated System to accurately and automatically predict the Condition of the manholes and eliminate the need for continuous manual inspections.

The system shall generate Real-Time Alerts with the Priority Assignment of High, Medium, and Low according to the condition of the manhole.

5. CONCLUSION

Finally, this paper demonstrates that Geo-tagging and digital monitoring are changing the way manholes are managed.

Unlike traditional methods, which are slow and rely on manual inspections, these technologies allow authorities to know the exact location of every manhole, monitor its condition in real time, and detect hazards early.Studies show that using geo-tagging with sensors, mobile apps, and GIS mapping improves safety, saves time, reduces costs, and helps plan maintenance more effectively. Cities that have adopted these systems have seen fewer blockages, overflows, and accidents, making the streets safer for everyone.Some challenges remain, such as the cost of technology, training staff, and keeping data updated, but these can be addressed with proper planning and research. In the future, using predictive tools, smarter sensors, and public reporting could make manhole management even more efficient.Overall, combining geo-tagging with digital monitoring offers a modern, proactive, and reliable way to keep manholes safe, functional, and well-maintained.

REFERENCES

[1] Y. Ding, B. Han, H. Jiang, H. Hu, L. Xue, J. Weng, Z. Tang, and Y. Liu. Application of improved yolov8 image model in urban manhole cover defect management and detection: Case study. Sensors, 25(13):4144, 2025.

[2] Varsha S, Sindhu P D, Vikram, "Manhole Visual Inspection System Using Deep Learning" IJCRT, Volume 12, Issue 4 April 2024

[3] Horsfall, O.M , Essenowo, I. E, "Manhole Cover Security And Monitoring System",March 2024,Vol:11, Issue:1 pp:(31-48)

[4] Dr. T. Amalraj Victorie, M. Vasuki, Suriya.P, " A Novel Approach For An Efficient Manhole Visual Inspection System Using Deep Learning Techniques", May 2024, Vol:11, Issue:05

[5] D. Pang, Z. Guan, T. Luo, W. Su, and R. Dou. Real- time detection of road manhole covers with a deep learning model. Scientific Reports, 13(1):16479, 2023

[6] Dr. V. M. Karthikeyan, Balaganesh. R. Jayaseelan. S, "Manhole Monitoring System", International Journal of Engineering Research & Technology (IJERT), 2022, ISSN:2278-0181.

[7] M.A. Ganpat, A. O.G. Bansoe, S. Shivaji, IJEAST, March 2022, Vol:6, Issue:11

[8] Dr.T. Menakadevi, Akash.M, Dilip kumar.B, Kannan.M, Chandra Mohan.S,"IoT Based Automated Manhole Detection",(IRJET), Apr 2021, Vol:08

[9] Sahu, S, & Sahu, N, (2021). Detection of Manhole Defects Using Deep Learning. In International Conference on Intelligent Communication and Computational Techniques (pp. 609-616). Springer, Singapore.

[10] Muralidharan, V., & Balasubramanian, R. (2020). Smart Manhole Covers monitoring system using IoT. In 2020 IEEE International Conference on Innovation Research and Development (ICIRD)(pp. 104-107).IEEE.