

Missing Feedback Loop and Disjointed Organizational Structure: Barriers to Quality Certification of Vehicular Emissions

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ABSTRACT

The effectiveness of vehicular emission certification is critically dependent on the operations carried out at PUC which needs to be compliant of Motor Vehicle Regulations 1989. Under the I&M (Inspection & Maintenance) program of Ministry of Road Transport & Highways (MoRTH), PUC emission testing and Vehicle fitness testing are run but managed separately. This fragmentation of structure creates hampering PUC performance. PUC centers have persistently underperformed in terms of quality certification of vehicular emissions as brought out by different studies and audit reports. Despite the regulatory framework in place, empirical evidence suggests that PUC centers have persistently underperformed in terms of quality certification. This research study pertains to tri-city area of Chandigarh, India.

When defects, errors or excessive costs occur, the causes of these can be found somewhere in the activities or in the gaps in communications. This paper investigates the systematic causes and thereupon comes to identifying the absence of a (i) structured feedback loop and (ii) organization structure unclear of relative authority levels, roles & responsibilities and reporting lines, which are the means to manage across it.

Through the regulations review, interaction with operators and thereupon the consequent data, this study reveals deficiency in performance monitoring, the feedback loop and accountability mechanisms across the PUC organization network. The feedback loop, at all, is not there. Without feedback loop there is no quality control. Quality control is fundamental to maintain control of every process-Juran. The existing org structure for PUC, disjointed from safety/fitness part, depicts informative only to vehicle owners (commercial or private). It requires having minimal alignment with quality system, portraying reporting lines, coordination and managing across functions.

Furthermore, regulatory enforcement is observed to be reactive, contributing to inconsistent certification standards and limited corrective actions. The absence of a structured feedback system prevents timely corrective and preventive actions (CAPA), while weak enforcement of SOPs results in procedural inconsistencies and poor data integrity. Over to that, the current organizational structure lacks clearly defined roles, technical oversight, and accountability, making regulatory compliance difficult to enforce uniformly.

Through this study, we emphasize that formalized feedback loop-integrating real time PUC data, audit findings and stakeholder's inputs- are essential to drive PUC towards continual improvement in emission certification. Restructuring PUC organization, it needs to be defined with roles, reporting lines and QA/QC, so as to attain sustainable compliance.

As the topic deals with vehicular pollution effecting environment and society, there is a need of policy level intervention so as to help attain SDGs.

Keywords: *Vehicular pollution, PUC certificate, Feedback loop, Organization structure*



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Introduction

Consequent to increase in vehicle population, the vehicular pollution has increased. Air pollution effects are harming society as well as environments. In these perspectives cities big or small are affected heavily. The effective control needs to be exercised over vehicular pollution. One such mechanism, the Pollution Under Control (PUC) certification, plays a pivotal role in ensuring that vehicles meet environmental norms related to air quality. Despite the well-established presence of PUC, their actual effectiveness and the overall quality of vehicular emission testing and certification processes fall under question.

Going little bit into the details for vehicular emissions, the enforcement and compliance program for Motor Vehicles consists of three main elements of vehicles test hierarchy (i) New Vehicle Type approval (ii) Conformity of Production and (iii) Inspection and Maintenance (I&M) Program. New vehicle Type Approval and Conformity of Production (COP) is under the management of MoRTH (Ministry of Road Transport & Highways).

I&M Program constitute in-use or on-road vehicle fitness testing and pollution under control (PUC) check, functioning under state transport Authority (STA) in each state. Under prescribed Motor Vehicles Rules the Transport Vehicles (Bus, Truck, car, Taxi or an Auto-Rickshaw) are required to undergo Annual Fitness Certification and periodical vehicular Pollution check.

Vehicle fitness certification and Pollution under control (PUC) Certification are managed separately meaning there by that PUC certification function is detached to operate as private entity.

A critical examination of PUC process framework reveals significant structural and functional inefficiencies which undermine the objectives of emission controls. Primarily these inefficiencies arise from two interconnected factors viz absence of robust feedback loop in the PUC system and the disjointed type of organizational structure for emission testing & certification and Fitness/ safety testing. The lack of feedback loop mechanism misses data concerning deficiencies in emission testing & certification and

enforcements. In the existing fragmented and siloed organization structure, different entities handle fitness safety testing and emission testing without communication and coordination which leads to misalignment in objectives and inadequate monitoring compliance.

In any regulatory process, feedback loops are crucial elements. They allow for continuous monitoring and refinement, ensuring that the goals of the system are achieved. For our case of vehicular emission testing and certification, the absence of such feedback mechanisms means that inefficiencies are not adequately identified or addressed, and non-compliance often goes unchecked and unchallenged. The feedback loop is a universal. It is fundamental to maintain control of every process. Quality control takes place with the feedback loop only. (Juran on 'What leaders need to know about quality'). Feedback mechanisms are essential for identifying gaps, understanding patterns of non-compliance, and continuously improving the emission testing and certification processes.

Equally concerning is the fragmentation within the organizational structure that oversees vehicular emission certification. Because of the disjointed structure, lapses often occur in communication and accountability, since each entity operates in isolation rather than in collaboration. With the result, the system lacks in the cohesion necessary to implement comprehensive and coherent emission standards, leading to inconsistent results and potential loopholes that may be exploited.

This research aims to explore these barriers to the quality certification of vehicular emissions. It also examines how the lack of feedback loops and disjointed organizational structures contribute to the inefficiency of the PUC certification process. Through investigating these systematic flaws, the study further identifies practical solutions that will help improve the implementation, and enforcement of vehicular emission standards. In doing so, it aspires to enhance the overall effectiveness of the PUC system, ensuring that it not only curtails emissions but also contributes to the broader goal of improving air quality and reducing the environmental impact of road transport. In the context of vehicular pollution and the PUC (Pollution Under Control) certification process, the significance of feedback loops and organizational

structure cannot be overstated, especially when considering their direct implications for both social and environmental impacts. Inefficiencies in emission testing go unnoticed, and regulatory actions remain reactive without a robust feedback mechanism. In fragmented structures, where emission testing and vehicle registration are handled by separate, disjointed agencies, accountability is diluted, and compliance is harder to monitor. A well-organized system ensures that both testing and enforcement are continuously aligned with the broader goals of emission reduction and quality management.

Other studies (Chakraborty & Das, 2019; Patel & Desai, 2018; Kumar & Singh, 2016) have analyzed the organizational gaps in vehicle registration and emissions testing processes, this study emphasizes the fragmented relationship between **vehicle fitness certification** and **PUC certification**—two test agencies that are essential but currently disjointed in the regulatory framework. This fragmentation represents a unique challenge to achieving effective vehicular emission control and certification, one that is distinct from previous research focusing primarily on the vehicle registration processes."

LITERATURE REVIEW

To combat vehicular air pollution, PUC centres were established across the country vide central motor vehicle rules 1989 (CMVRs 1989). In alignment to the topic and the context, we pierced through the literature and come across the research papers and studies conducted on PUC which enumerate the failures and inabilities in controlling vehicular emissions for number of reasons. However one particular aspect is very clear that no study or audit report has evaluated PUC's performance as at par.

In this bid we have examined the research papers and studies in national and global perspectives. Some of these are given along with the few important points, herein under:

2.1 National Perspective

2.1.1 Sharma, R., & Joshi, S. (2017). "Assessment of Pollution Under Control (PUC) certification System in India: Challenges and Recommendations."

Environmental Science and Policy, 10(2), 77-85.

This study explores the state of the PUC certification system in India, where vehicular emissions still remains a major source of pollution. The authors bring out that the fragmented nature of the regulatory bodies responsible for vehicle registration and emission testing. They in their paper identify the lack of clear communication between these agencies as a key barrier to improving PUC compliance rates. They suggest in their research that the government needs to create a centralized system which integrates PUC certification and vehicle registration with automated

reminders for vehicle owners to renew their certification periodically.

2.1.2 Kumar, P., & Singh, R. (2016) "Effectiveness of Periodic Vehicle Emission Testing in Urban Areas: A Case Study of Delhi." *Urban Environmental Studies*, 15(4), 102-113.

This case study deplors and analyzes the effectiveness of the PUC certification system in Delhi, India, which suffers from severe air pollution levels due to a large number of non-compliant vehicles. The authors argue that in the light of emission standards, enforcement is inconsistent for reasons of coordination between the agencies responsible for enforcement and testing. They recommend introducing a centralized database linking with vehicle registration records with emission testing data, thus improving the chances of timely PUC certification renewal and better monitoring of non-compliance.

2.1.3 Chakraborty, A., & Das, S. (2019). "Analyzing the Organizational Gaps in Vehicular Emission Regulation in Kolkata." *Environmental Management and Policy Review*, 11(3), 124-136.

In Kolkata, India, this study by Chakraborty and Das highlights organizational inefficiencies in the vehicular emission testing system in that city. The research brings out that testing stations are not properly integrated with the agencies responsible for vehicle registration. The resulting disjointed structure prevents effective communication about PUC renewals and follow-ups, contributing to high levels of non-compliance. In order to improve accountability and compliance, the authors propose a more unified approach where vehicle registration and PUC certification are handled within the same organizational structure.

2.1.4 Patel, H., & Desai, V. (2018). "Challenges in Implementing Emission Standards: Evidence from the Indian Subcontinent." *Journal of Environmental Policy*, 25(1), 63-75.

The authors explore the challenges in enforcing vehicular emission standards across various states in India, where emission testing is mandatory but being inconsistently implemented. They found out that many vehicle owners go for PUC certification during the registration or re-registration process, thereby often overlooking the periodic renewal requirement. The study suggests that by creating stronger linkages between the vehicle registration and PUC certification process—along with integrating feedback loops for periodic monitoring—could address these compliance gaps.

2.1.5 Garg, S., & Kapoor, P. (2020). "Public Awareness and Compliance with Vehicular Emission Standards in India: A Review of PUC

Practices."*Environmental Education and Awareness*, 14(2), 77-90.

This research focuses on the public awareness aspects of vehicular emission regulations in India. They argue that many vehicle owners understand the importance of registration and re-registration, but they lack in the adequate knowledge of the periodic nature of PUC certification for emission control. The study brings out that better communication and educational campaigns from regulatory bodies, along with improved integration between PUC and registration processes, could enhance compliance rates and overall air quality.

2.1.6 Singh, S., & Mishra, A. (2021). "Evaluating the Effectiveness of the PUC System in Mumbai."*Sustainable Transport and Development*, 7(1), 1-14.

The authors evaluated the PUC certification process in Mumbai, one of India's largest cities. In the city of Mumbai pollution levels are exacerbated by the growing number of vehicles. They found out that the PUC system, although present, suffers from gaps in enforcement and coordination in respect to ensuring periodic renewal of certification. The paper argues that improving the organizational structure by centralizing the PUC system and linking it with vehicle registration will help streamline enforcement to reduce emissions. Furthermore, the study emphasizes the need for regular audits and feedback mechanisms to ensure continuous improvement

2.2 Global Perspective

2.2.1 Vijayakumar, A., & Gopal, M. (2018). "Evaluating the Impact of Emission Standards on Air Quality: A Global Perspective."*Journal of Environmental Protection*, 9(2), 45-58.

This study assesses the global impact of vehicular emission standards on urban air quality, comparing various countries' emission testing protocols, including those focused on periodic PUC certification. The research highlights how a lack of feedback mechanisms between testing agencies and vehicle owners often results in compliance failure, especially in regions with disjointed regulatory structures. The paper emphasizes the need for an integrated system that involves real-time data sharing between emission testing facilities and enforcement agencies to improve compliance rates.

2.2.2 Zhang, Z., Wang, L., & Xu, J. (2020). "The Role of Organizational Integration in the Effectiveness of Vehicular Emission Regulations."*Environmental Policy and Governance*, 30(4), 289-303.

The authors in their study investigate the role of organizational integration in achieving effective vehicular emission control in developed nations. The research finds that fragmented regulatory structures, where emission testing and vehicle registration

processes are handled by separate agencies, impede the long-term success of emission standards. The study also emphasizes the critical importance of feedback loops to adjust emission testing protocols as technologies evolve. The authors propose an integrated model where emission data is shared in real time with government agencies to ensure compliance and create stronger accountability.

2.2.3 Dougherty, T., & Matthews, A. (2021). "Feedback Mechanisms in Environmental Regulations: Lessons from the Vehicular Emissions Sector."*Global Environmental Change*, 35, 91-101.

This research examines the critical role of feedback loops in environmental regulations with reference to the vehicular emission sector. The study finds that many countries with limited feedback mechanisms, particularly in developing regions, struggle with non-compliance and enforcement of emission standards. The authors argue for the establishment of dynamic feedback systems that can adjust to changes in both vehicle technology and emissions data, thus enhancing the reliability of emission certification processes like PUC.

2.3 Summarizing the literature Review

The review highlights the importance of organizational integration, the role of feedback loops, and the need for continuous monitoring in improving the effectiveness of vehicular emission testing and certification systems.

Global studies stress the significance of data sharing and coordinated efforts among agencies, while national level research studies provide context-specific insights into the challenges faced by countries like India. Both perspectives underscore the gaps in the current PUC certification systems and suggest that addressing organizational fragmentation and integrating feedback mechanisms could lead to more efficient emission control and a reduction in air pollution.

We say here that the above quoted studies talk about the disjoint between vehicle registration and PUC Testing process. However our study addresses the critical disjoint between vehicle fitness certification and the **PUC testing** process, which our research identifies as a significant barrier to effective vehicular emission certification.

Factors that impacts PUC performance (Quality certification)

The factors described below are the two major elements of PUC performance which are the cause of its under performance. These are Feedback loop and unclear organization structure

3.1 Feedback Loop: Feedback loop is a universal and it is fundamental to maintain control of every process. Quality control takes place by the use of feedback

loop. No structured feedback mechanism exists in PUC to transact information related to performance from PUC centre to the transport authorities. The performance deviations, equipment malfunctions, or any unfair practices go unnoticed or for that matter, are only identified post-violation.

3.2 Unclear Organizational Structure: For on-road or in use vehicles there is fitness testing and pollution under control (PUC) checks carried out under I&M (Inspection & Maintenance) program of Ministry of Road Transport & Highways. This program is managed by State Transport Authority (STA). The existing structure of I&M is described in Fig.-1 below:

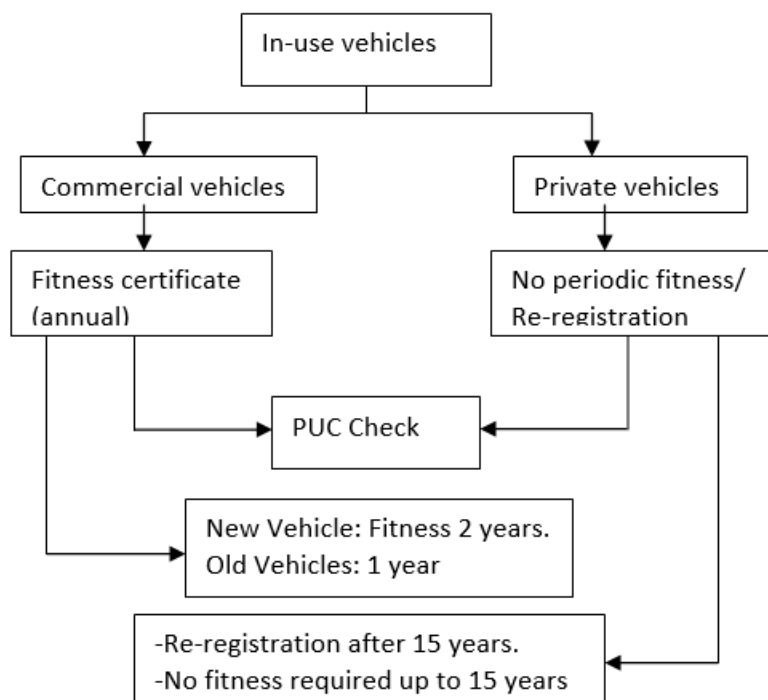


Fig.:1 Existing Inspection & Maintenance System in India
(Source: CPCB-2010)

The fitness Certification activity is carried out by the motor vehicle inspectorate attached to Regional Transport Offices (RTOs) under State Transport Authority in each State where the PUC certification activity functions as private entity. Because of this, the present structure gets fragmented creating void in organization structure for quality PUC certification. Further it depicts that it is informative to vehicle owners only. With the result the operators function independently without formal reporting lines or oversight mechanisms. Quality standards are either diluted or ignored. Suitable structure is crucial for achieving organizational objectives by ensuring coordination and focus.

OBJECTIVES OF THE STUDY

The PUC process is already overwhelmed with the errors, defects and chronic problems leading to its failures in delivering Quality PUC certification. PUC

centres were established to control vehicular emissions with the purpose that PUC certificate is fit for its purpose. Any product or service is fit for purpose if it meets (i) customer (vehicle owner) mandatory requirement of PUC certificate (ii) Protects human safety and (iii) Protects the environments (Juran on what leaders need to know about quality). In order to find answer so as to reach the purpose, the objectives of this research study are:

4.1 To study the (i) PUC process organization structure and (ii) feedback mechanism to establish the causes of the problem therein..

4.2 To make aware the PUC Management (Governance & Compliance-Transport Department) to the universal of feedback loop and organizational structure to implement in PUC by publishing this research based study and bringing it on a public information platform.

SCOPE OF STUDY:

This research study focuses on the functioning and synchronization of the two main bodies involved in the PUC certification process. One of them the Regulatory body is the Transport department and the execution is carried out by the PUC centre. This study examines the relationship between two regulatory agencies—the **vehicle fitness certification body** and the **PUC testing agency**—which are disconnected in practice, thereby contributing to regulatory inefficiencies. Unlike studies that focus on either vehicle registration or emissions testing, our methodology targets the fragmented processes between these two testing agencies, offering a fresh perspective on barriers to quality emissions certification.

METHODOLOGY

suitable structure is crucial for achieving organizational objectives by ensuring coordination and focus.

6.1 Real world Problem: Vehicular Air Pollution is on the rise & crossing above tolerable limits: Rising air pollution indicates that PUC certificate is issued to a vehicle irrespective of its condition whether the vehicle's emissions have met the prescribed standard specifications We can say "Rarely any vehicle Fail" in PUC certification. The result is that air quality is degrading day by day.

Problem statement: Missing feedback loop and unclear org structure impede quality certification of on-road vehicles' emissions.

6.1.1 Data and Data Sources

6.1.1.1 Secondary data: Data regarding organization structure that is organization of PUC is derived from CPCB-2010 (Status of the vehicular pollution control program) given above in 3.2 where the PUC organization structure is provided. It was not found in any PUC centre during survey.

6.1.1.2 Primary Data: To address the issues of "Missing Feedback Loops and Disjointed organizational Structures: Barriers to Quality Certification of Vehicular Emissions", a survey was undertaken in the tri-city area of Chandigarh. Data collection was carried out through carefully designed schedules and observations for 50 PUC centers. The schedules were structured to gather detailed information on the feedback loop and organization structure. Both the variables in question are missing.

6.2 Analysis to find root causes

In order to find out the root causes behind (i) not having Feedback loop between PUC centre and transport department and (ii) there is disjointed organization structure in The PUC centers for reporting, roles and responsibility along with

communication protocols, the four step diagnostic journey is used.

6.2.1 Four steps diagnostic Journey:

- (i) From problem to symptoms of the problem
- (ii) From symptoms to theories of causes of the symptoms
- (iii) From theories to testing of the theories
- (iv) From tests to establishing root causes

Let's walk through each step of the diagnostic journey.

6.2.2 Step-by-Step Diagnostic Journey

Step 1: From Problem to Symptoms of the problem

During data collection we observed these key symptoms in PUC operations:

- No feedback loop or regular communication between PUC centers and the Transport Department.
- No mechanism for review, monitoring, or correction of performance.
- Disjointed or non-existent reporting lines organization structure..
- Lack of clarity about roles and responsibilities among operators, regulatory authorities, and enforcement agencies.
- No internal audits or quality control measures visible at the centers.

We have identified systematic breakdowns in oversight, reporting, and accountability.

Step 2: From Symptoms to Theories of Causes

Theories of causes mean hypotheses:

- Theory 1: There is no feedback mechanism built into the operational framework of PUC centers.
- Theory 2: PUC centers operate without a clearly defined organizational structure aligned with regulatory requirements.
- Theory 3: Oversight agencies have not enforced standard communication, reporting, and accountability protocols.

Step 3: From Theories to Testing of Theories

Now, we proceed to **test** each of the theories to see if they are valid. This step involves collecting data, performing tests, or gathering evidence to either **prove** or **disprove** each of the theories we have come up with.

Collection of data: A survey was undertaken across 50 PUC centre for assessing the PUC process performance in the light of the problem. So our theory gets validated by the data: We find through data collection that:

- All PUC centers lack a feedback loop.
- All have unclear organization structures which even not displayed in PUC centre. This organization structure could be obtained from literature review.

This confirms that these are not isolated incidents, but systematic failures.

Step 4: From Tests to Establishing Root Causes

Now that theories have been tested and confirmed, we can formalize the root causes.

The Established Root causes are:

1. Root Cause 1: Absence of a Feedback System as a Structural Element
 - No digital or on line mechanism exists to transmit operational data (test results, calibration errors, violations) from PUC centres to the Transport Department.
 - Hence, no preventive or corrective action cycle can occur — making quality control impossible.
2. Root Cause 2: Lack of Organizational Accountability and Structure
 - Roles and responsibilities for the PUC process (operators, inspectors, enforcement agencies) are not clearly mapped and or charted.
 - This brings confusion about who is responsible for enforcing SOPs, audits, training, or equipment maintenance.
3. Root Cause 3: Regulatory Gaps and Poor Enforcement of SOPs.
 - SOPs may exist on paper but are not integrated into daily operations, nor is compliance monitored.
 - No performance metrics, inspection audits, performance reviews or disciplinary procedures are in place or practiced.

Now we proceed to analyze these causes with respect to the following points:

6.2.3 Analysis of established Root Causes

Analyzing each Root Cause:

The data collected from multiple PUC centers across regions confirms that two systematic deficiencies lie at the heart of quality certification failure: (1) the absence of a feedback loop between Pollution Under Control (PUC) centers and the Transport Department, and (2) an unclear and inconsistent organizational structure governing PUC operations. These have been diagnosed as the primary root causes obstructing the implementation of quality PUC certification of vehicular emissions. How these root causes impact the PUC performance and the relevant factors thereto. .

6.2.3.1 Absence of Feedback Loop

Despite the presence of test results and compliance data, no structured feedback mechanism exists to transact performance information from PUC centers to the transport department. This lack of real-time or

periodic feedback prevents the initiation of corrective or preventive actions (CAPA). Consequently, performance deviations, equipment malfunctions, or fraudulent practices go unnoticed or are only identified post-violation.

In quality management terms, this represents a breakdown in the “Check” and “Act” phases of the PDCA (Plan–Do–Check–Act) cycle, which is fundamental for continuous improvement. The absence of feedback also nullifies the opportunity for benchmarking, data-driven monitoring, or knowledge sharing among PUC centers.

6.2.3.2 Unclear Organizational Structure

Data reveals that PUC centers operate without a defined organizational hierarchy. There is ambiguity about the roles and responsibilities of centre operators, regulatory inspectors, and supervisory authorities. This sort of organization leads to inconsistent implementation of SOPs, weak enforcement of technical standards, and poor accountability.

In most cases, operators function independently without formal reporting lines or oversight mechanisms. The lack of defined escalation protocols or supervisory layers results in a regulatory vacuum. Consequently, compliance becomes discretionary, and quality standards are either diluted or ignored.

6.2.3.3 Combined Impact on Quality Certification

Together, the absence of feedback and lack of organizational clarity create a self-perpetuating cycle of underperformance. No mechanisms exist to detect or prevent substandard certification practices. Furthermore, without organizational clarity, even well-intentioned regulations remain unenforced due to unclear execution authority. These root causes explain the consistent failure of PUC centers to meet acceptable quality benchmarks despite regulatory guidelines on paper.

Three factors have been taken to go for discussions so as to provide a clear significance picture of these root causes.

(i) **Why** these root causes are critical barriers to performance that is Quality PUC certification.

(ii) **How** they lead to the symptoms observed (e.g., inconsistent certification, lack of trust, non-compliance)

And (iii) **these** causes are seen with references to quality management principles & standards (e.g Deming Cycle, ISO standards, and feedback systems). The ensuing discussion for the three factors is provided in Tables. (Table-1 to Table-3)

Table-1.

<i>Root Cause 1: Absence of a Feedback System as a Structural Element</i>		
Critical barriers to quality PUC Certification	How root cause lead to the symptoms observed (Link)	Looking at these causes. with references to quality management principles & standards
Critical Barrier Explanation: The absence of a digital or online feedback mechanism significantly undermines the effectiveness of quality control within PUC centres. Without a formalized system for transmitting operational data such as test results, calibration errors, or violations from PUC centers to the Transport Department, there's no real-time monitoring or intervention to ensure consistency and accuracy. This missing feedback loop prevents the identification of systemic issues and delays any corrective actions that might otherwise be taken.	Link to Symptoms: The root cause directly leads to inconsistent certification practices, as errors or deviations go unnoticed and unaddressed. Without proper tracking, there is no way to ensure that necessary corrections are made, which results in variations in the quality of emission testing. The absence of transparency also fosters a lack of trust among stakeholders (e.g., the public, government agencies, and management.) in the certification process, which ultimately reduces the credibility and effectiveness of emission control efforts.	Quality Management Connection: The lack of a feedback system directly contradicts the Deming Cycle (Plan-Do-Check-Act) , which emphasizes the importance of continuous feedback and improvement. In the absence of the "Check" and "Act" phases, any issues are left unresolved, impairing the overall quality control process. Additionally, ISO standards for quality management systems (ISO 9001) stress the importance of monitoring and continuous improvement, which is unattainable in this context due to the absence of feedback loops.

Table-2

<i>Root Cause 2: Lack of Organizational Structure and Accountability</i>		
Critical barriers to quality PUC Certification	How root cause lead to the Symptoms observed (Link)	Looking at these causes. with References to quality management principles & standards
Critical Barrier Explanation: The lack of a clear organizational structure and accountability in the PUC process is a significant barrier to the smooth operation of emission certification. When roles and responsibilities for critical processes such as inspections, SOP enforcement, and equipment maintenance are not clearly defined, it leads to confusion, overlaps, and gaps in execution. This structural ambiguity weakens the overall effectiveness of the certification system and hinders the allocation of resources or intervention when necessary.	Link to Symptoms: Without a well-defined accountability framework, there is little oversight or ownership of key tasks, which leads to inconsistent application of Standard Operating Procedures (SOPs). This results in non-compliance with established norms and standards, and leaves certain responsibilities—such as training, audits, and equipment maintenance—unattended to or poorly executed. This can contribute to unreliable test results, missed violations, and general inefficiency. The confusion around roles also leads to a lack of trust in the entire system, as stakeholders may perceive the process as unprofessional.	Quality Management Connection: The absence of organizational clarity undermines the core principles of ISO 9001 , particularly the focus on leadership and accountability . According to ISO 9001, effective leadership is essential for establishing clear roles and ensuring that everyone understands their responsibilities. This root cause also conflicts with the RACI matrix (Responsible, Accountable, Consulted, Informed), which is used to clearly delineate roles and responsibilities in processes. The lack of an effective accountability structure would disrupt this, leading to operational inefficiencies and quality control issues

Table-3

Root Cause 3: Regulatory Gaps and Poor Enforcement of SOPs		
Critical barriers to quality PUC Certification	How root cause lead to the Symptoms observed (Link)	Looking at these causes. with References to quality management principles & standards
Critical Barrier Explanation: Regulatory gaps, along with the poor enforcement of SOPs, are significant barriers that undermine the integrity of the PUC certification process. SOPs are crucial to maintaining consistency, transparency, and quality control; however, when these procedures are not enforced or monitored on a daily basis, they lose their effectiveness. The lack of performance metrics, regular inspections, audits, and performance reviews contributes to a regulatory void that allows substandard practices to proliferate.	Link to Symptoms: The failure to integrate SOPs into daily operations results in inconsistent certification processes, where certain PUC centres may follow the rules while others do not. This inconsistency increases the likelihood of non-compliance, with certain vehicles passing emissions tests that should fail, while others may fail due to procedural oversights. Additionally, the lack of disciplinary action or performance reviews means there is no incentive to correct inefficiencies or poor practices. This lack of regulatory oversight fosters a culture of complacency and erodes the trust of the public and regulatory bodies.	Quality Management Connection: The gap in regulatory enforcement reflects a failure to apply the Plan-Do-Check-Act (PDCA) cycle effectively, especially the "Check" and "Act" phases. Without systematic audits and performance reviews, it becomes impossible to measure performance and correct deviations. Similarly, ISO 9001 standards emphasize the need for ongoing monitoring and review of processes to ensure compliance and continuous improvement. The lack of enforcement mechanisms contradicts these foundational principles, allowing issues to persist and undermine the overall quality system.

RECOMMENDATIONS

Based on the diagnostic analysis and identified root causes, the key recommendations to establish a preventive, accountable, and performance-driven PUC system are given herein under:

1. Establish a Digital Feedback Loop
 - Real-time reporting of PUC test data to the State transport authority.
 - Auto-flagging of anomalies (e.g., unusually high pass rates).
 - Monthly feedback reports from the department to centres.
2. Define a Standard Organizational Model (Proposed Org structure) given after recommendations in Fig-2
 - Define roles for: PUC operator, supervisor, audit inspector, state-level nodal officer.
 - Use org charts and define vertical reporting lines.
3. Mandate and Enforce SOPs
 - Develop a SOP framework for PUC operations.
 - Make SOP compliance part of license renewal criteria for centres.
4. Introduce Preventive Quality Measures
 - Periodical internal & external audits.
 - Randomized inspections.
 - Training and re-certification of operators every 6–12 months.
5. Implement Feedback-Driven Improvement
 - **Corrective and Preventive Action (CAPA) System:** Introduce a structured CAPA framework to ensure that issues identified via feedback lead to documented and monitored action.

Hence the entire I&M system may be like the one shown in fig. 2 (Proposed Org Structure)

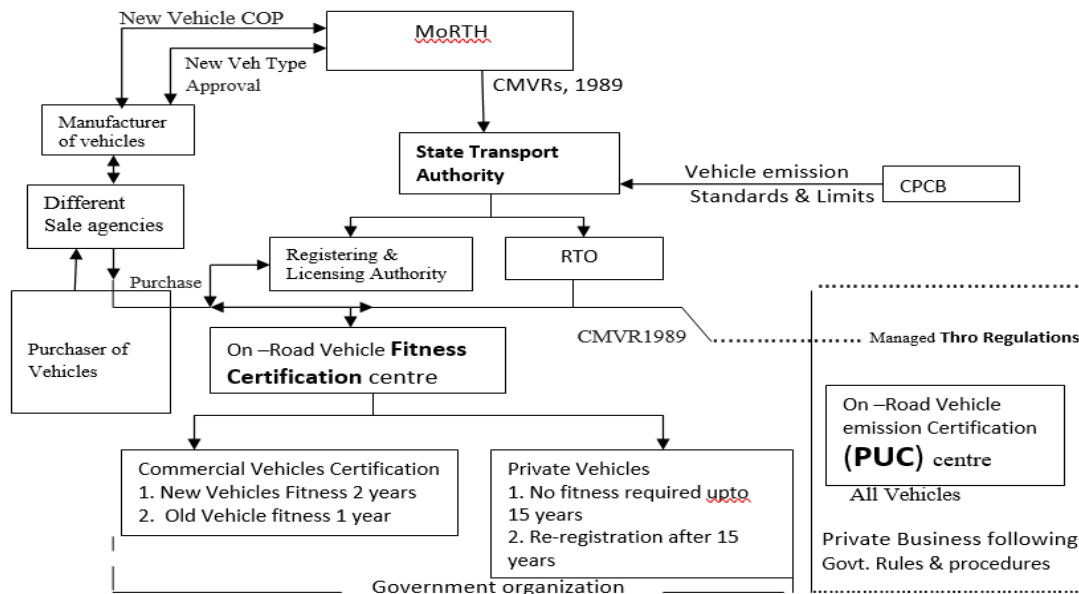


Fig. 2 Inspection & Maintenance (I&M) Structure

CONSLUSION

This study provides novel insights into the fragmentation between vehicle fitness certification and PUC certification, offering policy recommendations to address this gap. Unlike prior work that has focused on vehicle registration and periodic emission testing, our research identifies this critical disjoint as a key barrier to quality vehicular emissions certification."

The barriers to the effective quality certification of vehicular emissions outlined in this study stem from three core issues: the absence of a robust feedback system, a lack of organizational accountability and structure, and there upon ensuing gaps in regulatory enforcement. Together, these shortcomings create a fragmented and inefficient certification process that undermines efforts to ensure environmental compliance and improve air quality.

Firstly, the absence of a digital feedback mechanism prevents timely corrective actions and real-time monitoring, leaving emissions testing vulnerable to inaccuracies and operational inefficiencies. Secondly, the lack of clearly defined roles and responsibilities among key stakeholders—ranging from PUC operators to enforcement agencies—results in confusion, reduced accountability, and inconsistent implementation of Standard Operating Procedures (SOPs). Finally, despite the existence of SOPs, the poor enforcement and monitoring of these guidelines further exacerbates the problem, leaving the system open to misuse and non-compliance.

Addressing these barriers requires an integrated approach, one that combines technological

innovations, organizational restructuring, and stronger regulatory frameworks. By establishing a digital feedback loop, redefining organizational roles, and enhancing the enforcement of SOPs, the vehicular emissions certification process can be transformed into a more effective, transparent, and accountable system.

Ultimately, the proposed solutions can pave the way for more reliable emissions testing, greater compliance with environmental regulations, and a healthier, more sustainable environment. Moving forward, it is critical that both governmental bodies and private sector stakeholders collaborate to implement these changes, ensuring that the fight against vehicular pollution remains robust and dynamic in the face of evolving challenges.

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