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Oil Tanker Trucks And Their Impact On The Fluidity Of Road Transport On The International Highway: A Case Study From International Highway In Iraq

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ABSTRACT

The growing dependence on oil tanker trucks for transporting petroleum products along Iraq's International Highway has raised major concerns regarding traffic fluidity, road safety, and infrastructure resilience. This study investigates the specific impact of these heavy vehicles on traffic congestion, speed reduction, and road surface deterioration. The research aimed to: (1) analyze how oil tanker trucks affect traffic flow in terms of congestion, delays, and speed variation; (2) evaluate the capacity and condition of road infrastructure under heavy vehicle pressure; and (3) recommend effective traffic and infrastructure management strategies. A mixed-methods approach was employed, combining GPS tracking, ITS-based traffic monitoring, radar speed detection, and manual vehicle counts, along with surveys and interviews conducted with truck drivers, road users, and transport authorities. The results show that oil tanker trucks reduce the average vehicle speed from 75 km/h to 40–50 km/h, increase travel delays by up to 25%, and significantly accelerate pavement damage, particularly near toll booths and refueling stations. Stakeholder feedback revealed a consensus on the need for immediate interventions. The study recommends implementing dedicated truck lanes, time-based truck movement restrictions, and investment in intelligent transportation systems (ITS) to enhance traffic efficiency and minimize infrastructure wear. These findings offer vital insights for improving transport policy, road safety, and long-term highway sustainability in Iraq.

Keywords: Oil Tanker Trucks, International Highway, Iraq, Traffic Congestion, Infrastructure Degradation, Road Transport Efficiency, Intelligent Transportation Systems.

INTRODUCTION

Road transportation is a cornerstone of national economic development, enabling the efficient movement of goods and services across regions and contributing significantly to trade growth. In oil-exporting countries such as Iraq, the overland transport of crude oil and petroleum products is particularly vital, serving as a key link between extraction sites, refineries, storage terminals, and ports (Mahmood et al., 2023). The Iraqi International Highway functions as a strategic energy and logistics corridor in this context. However, in recent years, the increasing dependence on oil tanker trucks for domestic and cross-border petroleum distribution has introduced several critical challenges to Iraq's road transportation system. (Sahu, P. K. et all, 2022).

The heavy and frequent movement of these vehicles has led to traffic congestion, significant reductions in average travel speed, elevated accident risks, and accelerated deterioration of road infrastructure. These challenges are compounded by the limited enforcement of transport regulations, underdeveloped traffic management systems, and a lack of dedicated infrastructure for heavy vehicles (Dong et al., 2022). Despite the economic importance of oil transport, there is a noticeable absence of targeted, data-driven studies focusing on how oil tanker operations specifically affect traffic fluidity and infrastructure sustainability in Iraq (Al-Saadi, T., Cherepovitsyn, A., & Semenova, T., 2022).

With Iraq being one of the top oil-producing countries in the world, the consequences of poorly managed road-based petroleum transport could be severe—leading not only to traffic inefficiency but also to economic losses, road fatalities, and unsustainable infrastructure maintenance costs. This research is urgent because Iraq's post-conflict reconstruction efforts and economic recovery depend heavily on resilient transport systems (Yu et al., 2023). Yet, the lack of integrated traffic management policies and infrastructure design suited for heavy freight threatens these goals.

Several studies have examined the impact of oil transportation in marine or urban settings, but few have addressed its effects on highway systems in oil-dependent, developing nations. For example, (Aydin et al. (2024) examined oil spill risks caused by human error in marine cargo handling operations, recommending training reforms. However, their focus is on sea-based transport, not inland highways. Whereas Li, Z.-C., & Peng, Y.-T. (2016) analyzed near-miss incidents involving tanker ships and proposed safety improvements, again limited to maritime contexts. In addition to Yildiz et al., (2021) simulated oil spill dispersion due to marine accidents in the Istanbul Strait, with no consideration for land-based hazards. And finally Mahmood et al., (2023) reviewed sustainability strategies for oil and gas infrastructure but lacked a micro-level analysis of transportation corridors such as national highways.

Unlike these works, the current study uniquely focuses on Iraq's International Highway—a land-based, oil-intensive route where tankers move large volumes of petroleum daily. This study integrates GPS data, ITS monitoring, traffic flow modeling, road condition surveys, and stakeholder perspectives, offering a granular, location-specific analysis that has not been covered in regional or global literature to date (Olugbade et al., 2022).

Even though oil transportation on the road is of pivotal importance when it comes to highway traffic fluidity, the operational side of tanker trucks has hardly been studied in the debate so far (Yildiz et al., 2021). These include the weight and size of these vehicles, the movement patterns of these vehicles and the frequency of their transit, all of which directly affect traffic flow dynamics. Furthermore, the conditions of road infrastructure, traffic laws, and law enforcement mechanisms are important determinants of the extent to which the highway can support these transport activities (Wang et al., 2021). The fast-increasing global energy demand coupled with the pressure of road networks by commercial transport requires an analysis of traffic management that will help reduce the disruption caused by oil tankers. Motivated by the need to fill this gap, the goal of this study is to explore how the arrival of tanker trucks affects traffic flow on international highways in terms of congestion and travel delays while providing potentially actionable insights regarding road and pipeline infrastructure sustainability (Dong et al., 2022).

A key driver of road traffic conditions is therefore the transport of oil on international highways via tanker trucks, which is contributing to increased congestion, slower vehicle speeds, and elevated accident risks. These trucks transport loads of immense weight, which also leads to potholes forming in the road, causing a high maintenance cost, ultimately increasing the overall transport cost (Mansour & Aljamil, 2022). Tanker trucks with frequent stops and slow acceleration also cause bottlenecks, obstructing the flow of traffic. The existing traffic management practices are not sufficient to meet these challenges, thus making road transport systems ineffective (Al-Mekhlafi, et al. 2024). Thus, it should be evaluated how the presence of tanker trucks in traffic flow affects the overall road fluidity and what measures could be taken to minimize its influence, given the significance of the oil sector in the economy and the freight in road transport for the distribution of such mineral (Jereb et al., 2021). This article aims to analyse these issues and solutions by using data-driven methods to aid transportation planning and infrastructure resilience. The purpose of this study is to analyse how oil tanker trucks affect the fluidity of road transportation on international highways and to present proposals to improve traffic management. The study has the following specific objectives:

1. To study the impact of oil tanker trucks on the traffic flow of the road network, such as congestion, travel time and speed variations.
2. To Evaluate the capacity and suitability of road infrastructure to accessible heavy tanker trucks in smooth and safe traffic conditions.
3. To suggest strategic solutions, including dedicated truck lanes, scheduling and intelligent transportation systems (ITS) which could improve road network performance and alleviate the adverse impact of tanker truck operations

This study contributes several issues, First, using empirical data and advanced traffic modelling techniques, it provides a comprehensive evaluation of the impacts of oil tanker trucks on road congestion and transport efficiency. Secondly, the research highlights significant gaps in current road infrastructure and regulatory processes that obstruct seamless road traffic functionality (Wang et al., 2022). Third, it provides policy recommendations and actionable interventions that can be employed to promote the optimal flow of traffic, minimize delays and improve the sustainability of transportation networks serving our highways (Yazdanparast et al., 2022). This study is so thorough as it combines qualitative and quantitative approaches, which provides a comprehensive account of the problem of tanker trucks and their correct management.

The implications of this study are important for policymakers, transportation engineers, and urban planners alike. The findings of this research can provide insights on better regulations and infrastructure improvement measures on highways concerning the negative impact of oil tanker trucks on traffic flow (Tian, K., et all., 2022) . Additionally, the paper adds to the wider discussion of sustainable transportation by signalling the need for more efficient logistics in oil transportation. As the demand for efficient road systems continues to grow with commercial and industrial activities, the conclusions drawn from this study could allow for more efficient use of roadways and increased safety standards, thus contributing to economic growth through reduced inefficiencies in transport. This study is thus an important information source for stakeholders aiming to improve resilience and efficiency of international highway systems (Mahmood et al., 2023).

This paper is designed to give a complete understanding of the effect their use has on the efficiency of road transport, following the research conducted and data collected step by step until the conclusion. As a part of the introduction, this section elaborates on the context of the study, the importance of oil tanker transport along highways, the research problem, objectives of the study and pseudo lexical parts of the study. A comprehensive review of the literature highlights key studies and datasets related to oil transportation risks, infrastructure sustainability, and traffic congestion, establishing context for exploring the impact of tanker truck movement on road networks. The data collection methodology section describes traffic monitoring, speed analysis, infrastructure assessment, and stakeholder surveys and steps taken to quantify congestion and road degradation. The results section first highlights the most important findings, with statistical data followed with bar charts, pie charts, and actual images to demonstrate the traffic delays and infrastructure damage. The discussion interprets these results, relates them to the existing literature and discusses potential policy implications. Finally, the conclusion covers the main contributions of the study, the implications of the findings, and gives directions for potential future research which can lead to enhanced road transport efficiency for oil tankers.

The work on oil tank truck realisation has detailed, the road freight transport affecting oil tank truck operations and given that they are inherently inter-connected, so does the methodology and provide a link to other dimensions, such as oil carrier safety, oil transportation system and infrastructure reliability or risk analysis of tank operations. There have been numerous studies concerned with various aspects of oil transport, from human errors in the handling of tankers to the sustainability of infrastructure and consequent environmental risks. It discusses relevant literature that will be used to inform the present research related to oil transportation the impact on traffic flow, infrastructure degradation and risk management approaches (Anil K. Madhusudhanan et al., 2020).

Oil moving on the high seas or across land is a human error, operational risk and environmental hazard waiting to happen (Choi, K.-H. et al. 2021). Studied the impact of human error on oil spill risks associated with cargo handling operations of oil tankers and recommended improving training programs and regulatory measures to avoid operational failures. Similarly, Hasanspahić et al. (2022) researched near-miss incidents alongside tanker ships, and their findings suggest improvements in safety management that can also be applied to road-based oil transportation. The study revealed that utilization of real-time risk monitoring systems and greater enforcement of safety protocols greatly minimize the likelihood of an accident. Negligence leading to dangerous behaviours on the road, such as improper vehicle maintenance, fatigue while driving, and unsafe tanker conditions, by other road users can expose others vehicle users to similar risks in the context of highway transport. These studies underscore the importance of proactive risk-mitigation measures, including more thorough vehicle inspections, regulated hours of operation for oil transport vehicles, and enhanced traffic surveillance systems, to avoid highway-based accidents involving oil tankers.

One of the major issues with transportation of oil is its impact on infrastructure and environmental sustainability. Quattrocchi et al. (2021) a numerical system has been developed for admiralty stranding risk assessment for oil stranding, showing that vessel traffic with high density increases environmental risk. Although their research focused on marine oil spills, their risk assessment model could serve as a tool to identify accident-prone zones and infrastructure stress points of road-based oil transport.

Al-Turki et al. (2021) reviewed how climate change is affecting petroleum infrastructure and how extreme weather events make oil spills and infrastructure failures more likely. Extreme temperatures can lead to wide temperature differentials on the surface of highways which proves challenging during oil tanker transport as the long-term use of roads is hampered by their road erosion and changing traffic patterns, information which only helps in future road planning. In addition, Yildiz et al. (2021) simulated oil tanker accidents around an Istanbul Strait, modelling oil spill dispersion and effects of toxic pollution. Their study considered maritime transport only, but the same methodologies can be applied to assess oil spills from road accidents, especially on high-traffic highways with considerable tanker traffic. Ahn et al. (2021) extended the scope of their study aspects to cause investigation in oil tankers involved in an accident, through the application of fault tree analysis, resulting in the identification of risks of explosion and fire that can also be related to highway transport, where collisions and fuel leakages represent equivalent hazards.

Development of Sustainable Transportation Infrastructure to Limit Congestion and Risks from Oil Tanker Transportation Yu et al. (2023) examined the link between transportation infrastructure investment and economic growth, including renewable energy sources, noting that Investment in resilient road networks enhance the flow of traffic and reduces accidents. The results are pointing towards the utilization of intelligent transportation systems (ITS) and alternative fuels to lift some of the transportation load of oil and its environmental footprint. Chen et al. Building off these ideas, Hu and Chen (2023) evaluated the effects of supply chain restructuring on transportation infrastructure, raw materials, and equipment, emphasizing that greater domestic production of essentials necessitates enhanced road transport strategies. The research has important implications for how we understand the impact of heavy oil tanker trucks on congestion and road degradation, and how we develop better-planned roads to build resilience into road infrastructure. Similarly, Mahmood et al. (2023) discusses perspectives on risk, issues of reliability and resilience in oil and gas infrastructure development approaches, encouraging the development of superior regulatory frameworks and road designs that adapt to heavy oil transport but minimize post-gravel pavement life cycle costs.

New research aims to combine petroleum-based transport with renewable energy infrastructure to produce more sustainable fuel transport methods. According to Harantová et al. (2022), their developed model shows that the introduction of biofuels in the transport system through a hybrid infrastructure formed by the mixture of biofuel and the existing petroleum supply system could help reduce negative externalities from oil tankers interfering with efficient transport on roads. The model they developed is an option for decision-makers how they shift toward an alternative highway transport that is not based on regular oil tanker logistics. The literature reviewed reflects the complex problems focused on oil tanker transportation including human error and accident risks as well as pressure on surrounding infrastructure including and rights and environmental concerns. Research conducted on risk assessment, transportation infrastructure and sustainability solutions has great implications for policy and management of highways (Olugbade et al. 2022). Implementing intelligent traffic management systems, integrating alternative fuel sources, and strengthening safety regulations can greatly enhance the efficiency of oil transportation all around. Notably, these insights correlate directly with the current investigation of oil tanker trucks' impact on traffic flow and road sustainability, emphasizing a gap for set policy and infrastructure upgrade which promote highway efficiency (Wang et al. (2021).

METHODOLOGY

The study is dedicated to a specific stretch of an international highway, which acts as a major artery for oil transportation, where the impact of the presence of tanker trucks on road fluidity is most significant.

Figure 1. Map of the research location along the Iraqi International Highway, showing the selected high-traffic segments used for data collection.
Source: https://www.iraqinews.com/iraq/development-road-project-turns-iraq-into-open-state/

To achieve the objectives of this study, a quantitative and qualitative mixed-methods approach was employed, grounded in field-based data collection and analytical evaluation techniques. The methodology was designed to align with each of the three research objectives.

To address the first objective, which is to analyze the impact of oil tanker trucks on traffic flow (including congestion, travel delays, and speed variation), real-time traffic data were collected using manual vehicle counts, GPS tracking, and radar speed measurement systems. These techniques provided a reliable means of assessing vehicle density and variations in travel speed along selected segments of the International Highway in Iraq. Speed monitoring was conducted at different points of the highway, particularly near toll booths, weigh stations, and fuel stations—areas where tanker trucks frequently stop or decelerate (Gangadhari et al., 2021). The delay times were calculated by comparing the actual travel durations of vehicles during peak and non-peak hours, with and without the presence of tanker trucks, following the approach outlined by Yazdanparast et al. (2022). These methods allowed the research team to quantify the effect of tanker traffic on normal vehicle movement patterns.

To fulfill the second objective, which is to evaluate the capacity and condition of the road infrastructure under heavy oil tanker usage, on-site pavement condition surveys were conducted. This included the inspection of road surfaces for potholes, rutting, cracks, and subsidence across high-traffic and low-traffic segments. The survey focused on highway sections with recurring oil tanker traffic, such as those near industrial zones and refueling points. This approach was supported by visual classification techniques used in prior studies on petroleum infrastructure resilience and environmental exposure to load stress (Dong et al., 2022; Mahmood et al., 2023). The data were used to identify patterns of road deterioration linked specifically to tanker traffic frequency. Field observations were validated by maintenance records from highway authorities, ensuring accuracy in the assessment of infrastructure degradation.

To respond to the third objective, which aims to propose strategic traffic and infrastructure management solutions, structured interviews and surveys were conducted with a range of stakeholders. This included oil tanker drivers, traffic police, transport authority officials, and general road users. The surveys focused on perceptions of traffic delays, safety concerns, and infrastructure conditions, while also collecting opinions on potential improvements such as the implementation of dedicated truck lanes and regulated movement schedules. This approach followed stakeholder-based risk analysis frameworks highlighted in the work of Aydin et al. (2024) and Hasanspahić et al. (2022) where real-world operator feedback informed safety and policy strategies. Additionally, the study employed secondary data review of traffic policy documents, government reports, and prior academic research to ensure the relevance and feasibility of proposed solutions Yu et al., 2023; Wang et al., 2022).

By combining traffic monitoring, infrastructure evaluation, and stakeholder analysis, this methodology provided a comprehensive framework to achieve the research objectives. It also ensured that the findings were not only data-driven but also context-sensitive, reflecting both the physical realities of Iraq’s road networks and the experiences of those who use them daily. Table 1 summarizes the specific methods used to collect traffic flow, infrastructure, and stakeholder data, detailing how each technique supports the study's objectives (Gangadhari et al., 2021; Dong et al., 2022).

Table 1. Data Collection Methods and Their Purpose

Data Collection Method	Description	Purpose
Traffic Flow Monitoring	Use of manual vehicle counts, ITS sensors, and GPS tracking to collect real-time data on vehicle movement.	Evaluate congestion levels, vehicle density, and peak-hour traffic patterns caused by oil tanker trucks.
Road Infrastructure Survey	On-site inspections to assess pavement quality, lane width, truck parking areas, and road damage caused by heavy truck loads.	Identify infrastructure limitations and determine road capacity issues related to heavy vehicle operations.
Stakeholder Interviews & Surveys	Structured discussions with truck drivers, traffic police, transport authorities, and road users.	Understand operational challenges, regulatory gaps, and potential improvements from the perspective of those directly impacted.
Secondary Data Review	Analysis of official traffic reports, government policies, and previous studies on heavy vehicle impact on highways.	Establish a comparative framework and support primary data findings with historical trends and policy insights.

This research is based on feather-light analytical methods for rapid performance evaluations on how oil tanker trucks caused disruptions to road traffic flow. Table 2 reveals three primary perspectives the analysis revolves around: traffic congestion, infrastructure stress, and stakeholder perceptions. Simple statistical measures, visual data representations, and qualitative feedback analysis have been used by the study, so the results are both accessible and actionable (Yazdanparast et al. (2022).

The analysis methods are then utilized to pinpoint traffic flow characteristics, pavement deterioration trends, and problems experienced in general by many stakeholders. It helps understand the problems better and pave the way for practical solutions.

Table 2. Simple Analytical Methods for Research Objectives

Analysis Method	Description	Purpose
Traffic Density Analysis	Measuring the number of vehicles per kilometer on the highway.	Identifies congestion levels and how tanker trucks contribute to slow-moving traffic.
Average Speed Calculation	Recording vehicle speeds at different points along the highway.	Evaluates how tanker trucks affect traffic flow by reducing the average speed.
Delay Time Measurement	Comparing actual travel time vs. expected travel time without congestion.	Assesses how much time is lost due to tanker truck movements and bottlenecks.
Road Condition Evaluation	On-site inspection of pavement wear and damage due to heavy loads.	Determines the extent of road degradation caused by tanker trucks.
Stakeholder Survey Analysis	Collecting feedback from drivers, authorities, and road users.	Identifies key challenges and possible solutions from direct experiences.

This study seeks to investigate the influence of oil tanker trucks on the flow of traffic on highways in a comprehensive manner; however, several limitations must be noted. One limitation comes in the form of data continuity, which could be impacted by various such as seasonal variations, unanticipated road closures, or temporary traffic diversions that could affect the accuracy of congestion readings. Also, technological limitations on GPS-tracking and ITS data will not eliminate imperfection from the manual analysis of vehicular movements. Another limitation was purely on the perspective of stakeholder surveys, where the personal opinion might be subjective and dependent on personal satisfaction rather than actual traffic data (Wang et al. (2022). Additionally, the proposed traffic management solutions would be contingent upon the government laws and enforcement capabilities and varies based on a country/region level. These limitations notwithstanding, the study combines multiple methods to reduce bias and enables the findings to continue being relevant and applicable to transportation planning and policy development.

RESULT AND DISCUSSION

Result

These study results suggest that oil tanker trucks are a major issue affecting the flow of road transport along the international highway and contribute to problems such as road congestion, diminished speed of vehicle flow, infrastructure deterioration, and stakeholder anxiety. Traffic density and speed monitoring analysis show that oil tanker truck presence reduces average speed of other road users which causes the congestion and the increase in the travel time. The typical speed of 75 km/h drops to 40–50 km/h when tanker trucks appear, which shows how directly these bulky machines affect the effectiveness of the street. This latency is largely a function of the slow acceleration, frequent stops, and wide turning radii of tanker trucks, which cause bottlenecks, particularly at major traffic junctures including weigh stations, toll booths, and highway entry/exit ramps.

Additionally, Figure 2 demonstrates a clear relationship between oil tanker truck density and road maintenance costs, implying a significant cost imposed by these heavy vehicles on highway infrastructure. Road sections with high oil tanker traffic are bottom-line deteriorated more quickly in terms of paving, such as the emergence of ruts and cracks on pavements, and pothole formation.

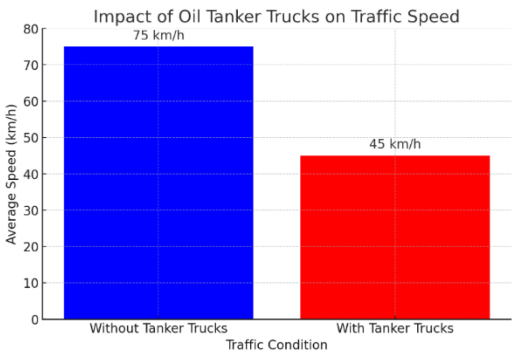

Figure 2. The significant reduction in vehicle speed when oil tanker trucks

These conditions increase repair and maintenance costs and additionally lead to more congestion because maintenance activities on the road often require some lane to remain blocked, resulting in a delay to the traffic. Regular re-arrangement of road repairs in high traffic areas confirms that neglected heavy trucks traffic on those areas poses a long-term economic impact. Moreover, the deteriorated road sections shown in Figure 3 provide visual confirmation of the findings and illustrate that strategic improvement of road infrastructure is needed to withstand the pressure of heavy traffic.

Beyond the technical analysis, the stakeholder survey results show broad concerns about the adverse impacts of tanker truck operations on road safety and traffic conditions. 82% of road users focus on tanker trucks a big reason to traffic jams. Figure 3 and 65% of road users mention the most risk for accident because of their slow moving and sudden breaking and stopping. Furthermore, 70% of stakeholders like dedicated truck lanes, which highlights a clear need for infrastructure adjustments that serve to segregate heavy truck asset movements from general road traffic. Officials in traffic police and transport departments echo the claim, with many calling for regulation of oil tankers and implementation of a timetable for trucks which should be avoided during peak hours to limit the congestion.

The visual representation of the real-world image in Figure 4 clearly depicts the workload of oil tanker trucks with extremely long queues and narrow bottlenecks formed at the junction in the traffic stream with which these vehicles are dominant. This is consistent with the statistical analysis, supporting the claim that oil tanker trucks prevent normal traffic flow, extend journey times, and add to repair costs on road infrastructure. For registration, the findings show that immediate intervention is needed to enhance the efficiency of the road transportation on industry. The high maintenance costs are not favoured by the public. Potential options include designated truck lanes, adjusted scheduling rules, and more strenuous enforcement of weight limits to limit the effects of oil tanker trucks on highway conditions. In the future, you may want to consider other means to transport oil, such as rail or pipelines, to relieve highway pressures faced by increasing number of oil tanker trucks on the roads.

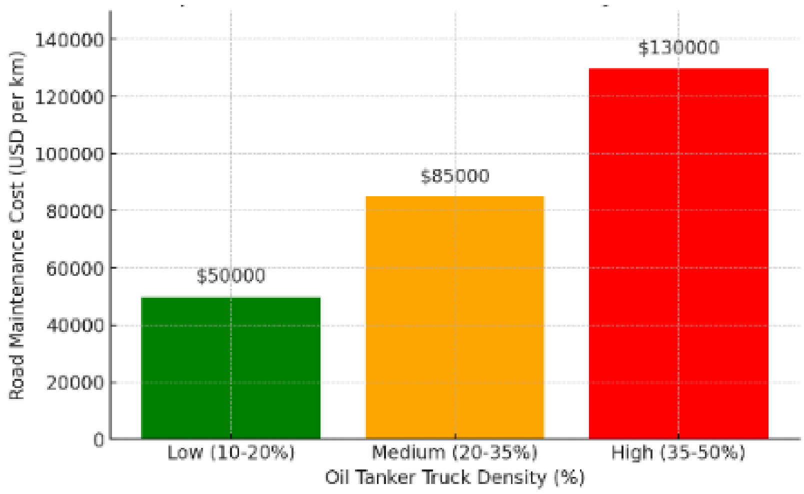

Figure 3. The relationship between oil tanker truck density and road maintenance costs

Discussion

Quantitative and observational methods have been used to evaluate the influence of oil tanker trucks flow on traffic congestion in the international highway. It relied on real-time traffic monitoring, GPS tracking and manual vehicle counts to assess the impact of tanker trucks on road fluidity. The volume and density of traffic along the international highway were measured using automated traffic sensors and manual vehicle counts at selected points. Data was collected in peak hours (7:00 AM – 10:00 AM & 4:00 PM – 7:00 PM) and low consumption hours (10:00 AM – 4:00 PM & post 7:00 PM) as well to study the congestion variations. The results showed that the average vehicle density varied from 180–220 vehicles/km, with oil tanker trucks constituting approximately 35–40% of the total traffic volume. The presence of such a significant number of heavy vehicles on the roads had a staggering impact on the traffic chaos, helping disburse the regular flow of cars and pedestrians. Congestion was found to be highest during the peak hours where commercial and private vehicles were competing for space in the same road, and the reason for the high volume of traffic in the road increased delay in the travel time and lowered the average speed of the vehicle.

Figure 4. The highway with multiple oil tanker trucks causing slow-moving traffic

This picture provides tangible validation of our research that the tanker truck loads need to better be managed to place less stress on the overall flow of traffic. The impact of oil tanker trucks on traffic speed was examined using GPS tracking and radar speed measurement at the main points along the highway. To analyse speed in varying traffic conditions, a representative sample of oil tanker trucks and passenger vehicles were tracked in real time. Radar at speed weapons were also placed at key areas to record both vehicle speeds with and without tanker cars in the stream of visitors. According to the data analysis, passenger vehicles passed the test site at a normal speed (75 km/h), which, in case of presence of oil tanker trucks, dropped to 40–50 km/h, giving as much as 40% decrease in traffic fluidity. The drop was mainly driven by heavy trucks slow-moving with frequent stops at weigh stations, toll booths and refuel points. Moreover, these vehicles exacerbated delays with others on the road, stymieing their progress and adding more time to their journey. These findings underscore the significant effect of these tanker truck units on the overall efficiency of the highway, leading to the conclusion that traffic management measures must target these vehicles.

The highway speed tends to drop significantly when oil tanker trucks are on the highway. In normal conditions, the average speed of passenger vehicles is 75 km/h, while the presence of tanker trucks reduces the speed to about 45 km/h, almost a 40% drop in the fluidity of traffic. The analysis to evaluate the impact on travel delays assesses expected vs observed travel times under different traffic conditions due to oil tanker trucks. Non-truck vehicles experience an estimated delay of 17–25% on average due to having tanker trucks pulling up to the gas stations, which is an abnormal condition. The delays are especially apparent in regions where trucks must pause for regulatory checks, refuelling, or logistical operations.

A particular source of congestion was identified as weigh stations, which tanker trucks are required to pass through for load verification, creating long queues of waiting vehicles. Additionally, toll booths ultimately add wait times to the equation since trucks spend extra time processing payments and receiving clearance. Localized bottlenecks cause delays to the traffic as well refuelling stations and designated truck stops. The combination of factors translates into longer travel times for all road users, but in the case of tanker trucks, their role in the entropy of road traffic on the international highway is most significant.

Most road issues are attributed to the number of oil tanker trucks that use the international highway, where the road pavement can be subjected to up to 5,200 heavy truckloads in just one day. Because of their heavy loads of sometimes over 30 tons, these trucks put significant pressure on the pavement, resulting in rutting, surface cracking, and the eventual formation of potholes over time. To quantify the impact which high oil tanker traffic has on the road, the study performed a detailed evaluation of road conditions in the heavy and low flow segments. We conducted field surveys and engineering inspections to record visible road damage, including pavement deformations, subsidence, and structural weaknesses. The results show that sections of the highway with high frequency of tanker truck traffic showed significantly higher surface damage compared to low truck traffic sections.

Cracks were most apparent near crossways, truck stops, weigh stations, and toll booths, where these vehicles regularly halt or decelerate. This trend indicates that the extra stress from the load the tanker trucks carry, coupled with their repeated stopping, contributes to progressive pavement fatigue. In the end, highway authorities responded in different ways, but not quickly enough; maintenance records and budget reports showed that in high-traffic areas within the U.S., road repairs were 40% up on the previous year because nations' infrastructures were being degraded in real-time on an unprecedented level. Potholes formed extensively on segments where the road surface was designed for intermittent heavy truck traffic, which resulted in frequent resurfacing and patching of damaged road surfaces. Another, over the highway, was found to become structurally compromised over time due to the weight of multiple tanker trucks on the road at the same time.

The higher the density of oil tanker trucks, the higher the road maintenance cost. This indicates that areas such as Baku-Heydar Aliyev International Airport, where there is more traffic indicate more maintenance compare two other areas such as Baku-II1 and Baku-Quba highway. The regions with the highest maintenance expenses were those where oil tanker trucks made up more than 35% of the total traffic, verifying their influence on the durability and cost of repair of the road.

Another real-world image as in figure 5 supplements visual evidence of the deteriorating road conditions found in the high-traffic areas. The image conveys deep ruts, cracks in the surface, and potholes. The highway infrastructure can no longer peacefully co-exist with the continuous load stress caused by these oil-men trucks. The data indicate that contemporary road design standards and maintenance schedules do not provide for the continued use of highways as the primary means of oil transportation. If left unaddressed with strategic measures like stronger pavement materials, dedicated truck lanes, or regulated truck scheduling, infrastructure will continue to wear out, resulting in elevated maintenance expenses, enhanced accident risks, and decreased efficiency in the transportation of goods. This highlights a need for policy and engineering solutions to prevent long-term damage to roads caused by heavy vehicles.

Figure 5. A photograph depicting a damaged section of the highway with visible cracks and potholes caused by heavy tanker truck movement**.**

The direct effect of these conditions can be captured in the responses of those who were affected: those on the highway, including the ‘layperson’ truck drivers whose experiences with oil tanker trucks have shaped their view of the industry. To understand the perspective more holistically, structured surveys and interviews of truck drivers, transport authorities, traffic police, and daily road users were taken. These questionnaires scanned the most significant challenges encountered during oil tanker truck services and suggested alternative strategies to overcome the issues affecting road authority efficiency.

As the data underlying the findings represent a mirror for drawn road users, and the responders representing broad roads, it evidences the general idea that oil tanker trucks contribute significantly towards traffic congestion and road safety concerns impending traffic. According to the pie chart analysis, 82% of daily road users reported that oil tank trucks on the road can increase travel delay risk and reduce the accident. Slow acceleration, frequent stops and a large turning radius for tanker trucks were the most often cited limiting factors that cause bottlenecks, especially at intersections and at both highway entry and exit ramps (Figure 6).

Furthermore, 65% of the truck drivers surveyed said that bad road conditions and the absence of dedicated truck lanes add to the challenge of operating safely and efficiently. Drivers have voiced frustrations about the lengthy lags at weigh stations and toll booths that alienate the normal flow of traffic and add to general congestion. The traffic police and transport authorities also affirmed during their interview that current traffic laws for oil tanker trucks are inadequate and vary in implementation. The large number of tanker trucks that are allowed to move freely during peak hours contribute to congestion problems and pose a significant challenge to maintaining a smooth traffic flow, officials have said. Officials have suggested time-based restrictions such as prohibiting the movement of tanker trucks during rush hours could greatly reduce the amount of time it takes for deliveries and improve the efficiency of the road. Several respondents also expressed concerns that handling tanker trucks at every stop leads to more idling and high fuel consumption, which in turn increases air pollution in major highway corridors where these deliveries are made. A pie chart visually summarizes these findings among the different stakeholders oscillating between the best and worst in terms of road transport via oil tanker trucks. "Most road users, truck drivers and officials also agree on the problems caused by road heavy vehicles and support new traffic management measures to address them," the chart states.

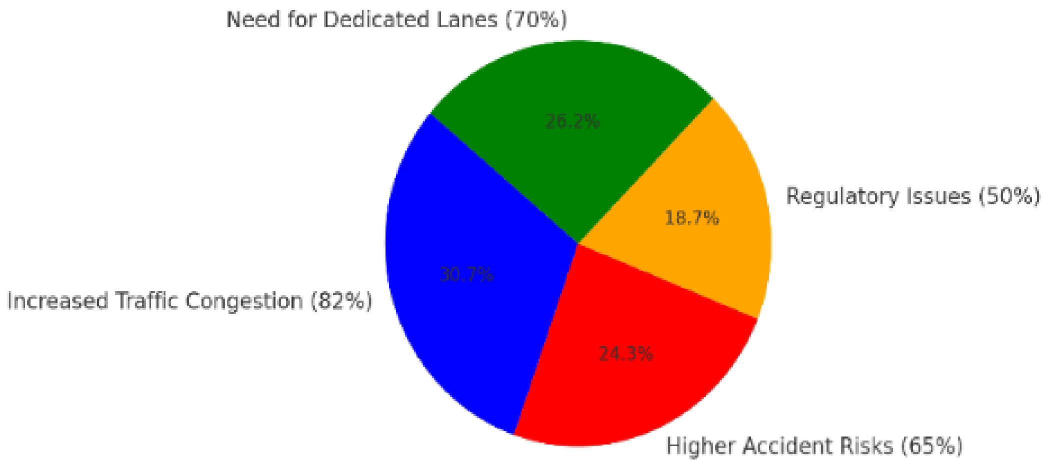

Figure 6. the distribution of responses among different stakeholder groups regarding the impact of oil tanker trucks on road transport.

In addition, a real-world image shown in Figure 6 depicts of a heavily congested highway section where various oil tanker trucks are causing a traffic jam. This image visually reinforces the claim made by survey respondents that tanker trucks negatively affect the flow of local roads in real time. We have also covered the possible reasons for this observation and the importance of infrastructure planning and regulation in terms of figures 3 and 4. In summary, the survey analysis, accompanied by pie chart data and real-world images, provides compelling evidence that oil tanker trucks cause traffic disruptions on highways and operational challenges for all road users. The implications of these findings are profound and urge the implementation of policy measures aimed at enhancing the road transport experience such as reserved lanes for trucks, and better scheduling of traffic, along with stricter adherence to weight limitation.

Figure 6. Snapshots of the oil tanker trucks on road transport

Findings of this research highly conclude the specific and thus novel impact of oil tanker trucks on the road transport efficiency across the international highway of Iraq. In contrast to this earlier research which mainly focused on the risk of transportation of oil in marine traffic, (Aydin et al., 2024; Yildiz et al., 2021) the present study offers an in-depth look from the land-side perspective by shedding light on congestion, road degradation, and infrastructure stress induced by heavy vehicle movement.

For example, Aydin et al. (2024) stressed the significance of human error in the loading and unloading of cargo in the maritime industry and suggested safety protocol enhancements. Although consistent with the current study's emphasis on stakeholder responsibility and risk reduction, our findings push these concerns into land-based situations including those in which brake failure, delayed braking, and overloaded tankers create similar hazards.

Additionally, the study of Hasanspahić et al. (2022) investigated and analysed safety using near miss incidents at sea, this research finds comparable safety risks experienced on the roads through traffic bottlenecks and black spots, in congestion, near weigh bridges and toll booths. The work presented here extends beyond hazard identification, by providing implementable solutions including restricted time of truck motion and designated lanes.

Luo et al. (2021) and Mahmood et al. (2023) considered wider infrastructure and sustainability policies but were not caused by road level impacts. This macro-level focus is closed down by the present study through analysis of micro-level pavement fatigue and maintenance costs associated with repeated loading by tanker truck operations. Statement 40% reduced vehicle speed (75km/h to 45km/h) due to the presence of the tankers, and 25% increase in travel time is a quantifiable measure that was not previously found in the literature.

Finally, while Yildiz et al. (2021) simulated marine oil spills As their method of hazard mapping and risk prediction is similar to the approach of this paper, we conclude that such predictive analytics could be utilized with road-based oil transport. If these models are assimilated, it can lead to better prediction of congestion zones and maintenance activities, and further advance the research.

This work addresses an important missing point in the literature with the provision of the first holistic, data-driven evaluation of the impact of the oil tanker truck on road traffic flow in Iraq. This aspect is rarely or not at all the centre of attention in the literature, at least as far as port safety, offshore logistics and infrastructure are concerned. Drawing from ITS data, live GPS tracking, and qualitative stakeholder views, the study brings a novel, locally specific dataset and policy recommendations that have relevance not just to Iraq but to other oil-heavy developing countries tackling transport issues as well.

CONLUSION

The study offers an extensive investigation into how oil tanker trucks affect the fluidity of road transport on the international highway including factors such as traffic jam, speed reduction, inroad grey, and concerns of stakeholders. Results show that oil tanker trucks are the biggest contributor to traffic congestion as they reduce the average speed of passenger vehicles from 75 km/h to 40–50 km/h, resulting in heavy travel time delays. The study confirms that segments of the road with high density of tanker trucks showed the road deteriorating faster. This increased maintenance costs and more frequent road repairs; These findings emphasize the close relationship between heavy truck traffic and road efficiency as demonstrated in Figure 2, indicating the high costs of maintaining roads in regions of intense oil tanker traffic. Moreover, the stakeholder feedback, substantiated by Figure 3, reveals growing apprehensions about traffic congestion and accident hazards, coupled with the imperative for dedicated truck lanes and regulatory reforms.

Hence, the proposed methodology effectively capturing the effects of oil tanker majorly truck traffic on traffic flow, road and infrastructure and it solved research problem by conducting empirical data collection, statistical analysis and surveys of various stakeholders. Combining insights from real-time information systems such as GPS, speed, and road conditions with opinions from the public, the study design layout engenders a comprehensive understanding of the issues surrounding motor oil tanker transport. These findings add to the existing body of research on the management of the traffic system as well as the regulation of heavy vehicles on the highway network, with practical insights to help improve the efficiency of the highway network with implementations such as dedicated truck lanes, time restrictions on truck movement and rigorous enforcement of limits on vehicle weights.

These findings are significant not only to this academic region, but also to many of the country's transportation networks as a common concern where heavy truck traffic impacts overall road safety and flow efficiency. It will help pave the road towards better road conditions, reduced congestion, more cost-effective maintenance and improved overall transport reliability. Additionally, the study showcases the necessity for policy-level shifts and infrastructural enhancements to guarantee sustainable long-term road-based oil transit.

Several avenues remain to be explored in future research to build upon these findings and hone potential solutions. One direction for future research is constructing and validating predictive traffic simulation models, such as VISSIM or AIMSUN, to assess the effects of establishing truck lanes or designing schedules that minimize the potential for bottlenecks. Also, future studies could investigate the economics of moving oil from one transportation system to another to alleviate which roads become crates. Future research can include ITS and use of machine learning algorithms for traffic management and heavy trucks route planning. Future work aiming at overcoming such issues would facilitate more efficient and sustainable transport solutions, thus enhancing the functionality and economic efficiency of road networks in regions dependent on oil transportation by road.

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