Scientific Reviews & Chemical Communications

Sci. Revs. Chem. Commun.: 3(3), 2013, 161-171
ISSN 2277-2669

FUEL ADULTERATION CONSEQUENCES IN INDIA : A REVIEW

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(*Received : 17.09.2013; Revised : 26.09.2013; Accepted : 28.09.2013*)

ABSTRACT

The quantum of petroleum product utilization in India is increasing due to increase in population, urbanization, development activities and changes in life style, which leads to widespread pollution in the environment. Thus tailpipe emissions from low level public transport such as auto rickshaw is a menace and become a serious problem due to their contribution in pollution and bypassing the subsidized kerosene to adulteration market. As fuel prices rise, the public transport driver cuts costs by blending the cheaper hydrocarbon into highly taxed hydrocarbon. The blending may be as much as 80-90%. Fuel adulteration is essentially an unintended consequence of tax policies and the attempt to control fuel prices, in the name of fairness. Air pollution is the ultimate result. This problem is not unique to India, but prevalent in many developing countries including those outside of south Asia. This problem is largely absent in economies that do not regulate the ability of fuel producers to innovate or price based on market demand. In the present paper developed techniques for fuel adulteration with kerosene and resulting tailpipe emissions causing environmental impacts has been studied.

Key words: Fuel adulteration, Gasoline, Kerosene, Pollution, Tailpipe emissions.

INTRODUCTION

Where different products of comparable qualities have different prices or consumers have no efficient tools to distinguish similar products of different qualities, unscrupulous operators will always try to exploit the situation for illegal profits. Illegal practices in the retail business are a global phenomenon, and fuel adulteration is one of the major abuses along with under-dispensing products to customers. These practices lead to losses in several areas, which include damaging engines and worsening air quality[1]. Evading fuel taxes reduces government revenue. Under-dispensing supplies to consumers lead to consumer losses. Doping gasoline with kerosene can leave harmful deposits in engines[2]. In India; the adulteration of gasoline is normally indulged primary due to the significant price differential between products.

Adulteration is defined as the illegal or unauthorized introduction of foreign substance into gasoline or similar substance, with the result that the product does not conform to the requirements and specifications of the product. The foreign substances are also called adulterants, which when introduced alter and degrade the quality of the base transport fuels[3]. Gasoline is a major transport fuel in India. Adulteration of the fuel at the point of sale and during transportation has become an acute problem in the country. Transport fuels (gasoline and diesel) are often adulterated with other cheaper products or by-product or waste hydrocarbon

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stream for monetary gains. For example, gasoline is widely adulterated with kerosene. With large number of adulterants available in the market, both indigenous and imported, the magnitude of the problem of fuel adulterations has grown into alarming proportions in the past few years. Financial incentives arising from differential taxes are generally the primary cause of fuel adulteration. In South Asia, gasoline carries a much higher tax than diesel, which in turn is taxed more than kerosene. Industrial solvents and recycled lubricants are other materials with little or no tax. Adulteration of gasoline and diesel is indulged primarily due to the significant price difference between these products and the adulterant. Various estimates have been made of the extent of financial loss to the national exchequer and the oil companies as a result of diversion of PDS kerosene, use of off-spec, low value hydrocarbons mixed with petrol/diesel, evasion of sales tax, etc.[4]

Adding low-taxed or subsidized kerosene to gasoline increases engine deposits and emissions. Also leading to a loss of government fiscal revenue is unlikely to have adverse environmental impacts.

EXPERIMENTAL

Literature review

Air pollution caused by automotive fuel emissions, especially NO_x, PM, CO and unburned hydrocarbons (HC), has been a noteworthy matter. Extended research on the effects of fuel properties on the emissions and engine performance has been performed worldwide[5]. In India, ambient air pollution is one of the major factors of hazards to human health[6]. The ambient air pollutants (AAP) such as SO_2, NO_x, particulate matter (PM), volatile organic compounds (VOC's) and polycyclic aromatic hydrocarbon (PAHs) are emitted from the automobile exhausts and industrial activity[7]. Exposure of AAP is an important cause of morbidity and mortality in India[8]. Adulteration of gasoline and diesel is as rampant in South Asia as it is elsewhere in the world. In South Asia, gasoline carries a much higher tax than diesel, which in turn is taxed more than kerosene. Adulteration increases emissions of harmful pollutants from vehicles and worsening urban air pollution that could cause adverse impact on health. An overview of the scope of the problem and some technical data on the gasoline and diesel adulteration was reported. Fuel adulteration can increase the emission of hydrocarbons and PM[10]. Air toxin emissions, such as benzene, depend mostly on fuel composition and catalyst performance. Polyaromatic hydrocarbons (PAHs) in the exhaust are primarily due to the presence of PAH in the fuel itself and partly due to PAH formation by fuel combustion in the engine. The result showed that addition of kerosene in gasoline results in higher level of emission of hydrocarbons, CO and PM, even in catalyst equipped cars. The emissions of air pollutants was reported due to adulteration of fuels that depend on maintenance of engine, fuel quality, air-fuel ratio, engine speed and load, operating temp. and whether the vehicles are equipped with a catalytic converter[9]. They have used five different compositions of petrol in kerosene and tested for emission and air pollution from petrol engine. It was observed that as the percentage of kerosene in petrol increased the concentration of SPM and CO also increased. Several reports indicate that adulteration of fuel with solvent, increase ambient air pollutants like HC, CO, NO_x, SPM[10].

The literature verifies that PM emissions generally increase or decrease in relation to the sulphur concentration. The sulphur content and the density of the white spirit as measured were relatively lower than the automotive diesel. Sulphur in the fuel results in sulphates that are absorbed on soot particles and increase the PM emitted from Diesel engines. In addition, the use of fuels with higher density results in higher emissions of PM and smoke[11].

The primary cause of adulteration is the greed fuelled by differential tax system[12]. For example, in south Asia, gasoline is taxed most heavily, followed by diesel, kerosene, industrial solvents and recycled lubricants, in that order. The fact that adulteration of gasoline by diesel and that of diesel by kerosene, is difficult to detect, combined with the differential tax structure makes such adulteration financially alluring, even though it is illegal. Mixing kerosene with diesel does not lead to an increase in tailpipe emission, but contributes to air pollution indirectly in South Asia. The diversion of kerosene for adulteration drastically brings down its availability, to the poor households, who turn to bio-mass for the purpose of cooking. This leads to an increase in the indoor air pollution and consequent ill effects on health. For the prevention of adulteration, monitoring of fuel quality at the distribution point, therefore, is highly essential. In the Indian context, the gasoline is adulterated by mixing diesel and diesel is adulterated by mixing kerosene. This is because these types of adulterations when limited to small volume % are difficult to detect by the automobile user.

Consequences of adulterated fuel

Fuel Adulteration of transport fuel, which is currently a very flourishing business in our country, can lead to economic losses, increased emissions & deterioration of performance and parts of engines using the adulterated fuels.

One conservative estimate is that the country looses more than Rs. 50,000 crores per year just from the adulteration loss, not counting the health cost and other indirect loss of efficiency[13].

Some of the effects of adulteration are outlined below –

(i) Mal-functioning of the engine, failure of components, safety problems etc. The problem gets further magnified for high performance modern engines[14].

(ii) Increased tailpipe emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM) can also cause increased emissions of air toxin substances[15].

(iii) Adulteration of fuel can cause health problems directly in the form of increased tailpipe emissions of harmful and sometimes carcinogenic pollutants[16]. While indirectly in the form of diversion of kerosene to the automobile sector for adulteration, thus prompting the use of biomass as domestic fuel which in turn leads to health problems of various types due to indoor air pollution. It may be noted that all forms of adulteration are not harmful to public health. Some adulterants increase emission of harmful pollutants significantly, whereas others have little or no effect on air quality.

(iv) Significant loss of tax revenue: Various estimates have been made of the extent of financial loss to the national GDP (Gross Domestic Product), as well as the oil companies as a result of diversion of kerosene, which is mixed with petrol and diesel.

Types of fuel adulteration

- Blending of lubricants into kerosene as a substitute for diesel.
- Blending of kerosene into petrol.
- Blending of kerosene into diesel and
- Blending of used lubricants into diesel[17]

Codes, standards or specifications for the gasoline and diesel have been laid down in different countries. National or other legally enforceable specifications represent the minimum quality that must be supplied and it is implicit that engine designers should ensure that their vehicles will run satisfactorily on such a quality of fuel. In India, the Bureau of Indian Standards (BIS) notifies the requisite specifications for petrol and diesel. Annexure I & II show BIS specifications for diesel and gasoline that are being implemented all over the country except in four metros, while in four metro cities Bharat stage-II fuel specifications are implemented.

Blending or mixing of adulterants into the base transport fuels exists in various forms and both the type and quantity of adulterants vary from place to place. Moreover, profitability, availability and blendability are the prominent factors governing the choice of adulterants.

Annexure I: BIS diesel specifications (IS 1460: 2000)

S. No.	Characteristics	Unit	Requirements
1.	Acidity, inorganic	Nil	
2.	Acidity, total, mg of KOH/g, max	mg of KOH/g	0.2
3.	Ash, max	% mass	0.01
4.	Carbon residue (Ramsbottom) on 10% residue, max	% mass	0.3 Without additives
5.	Cetane number (CN), min OR		48
	Cetane index (CI), min		46
6.	Pour Point, max as per OCC Directive		
	(a) Winter (Nov-Feb), max	°C	3
	(b) Summer, max	°C	15
7.	Copper strip corrosion for 3 hrs @100°C, max		Not worse than No. 1
8.	Distillation:		
	(a) at 350°C, min recover	% volume	85
	(b) at 370°C, min recover	% volume	95
9.	Flash point		
	(a) Abel, min	°C	35
10.	Kinetic Viscosity @40°C	cst	2.0-5.0
11.	Sediment, max	% mass	0.05
12.	Density @15°C	kg/m^3	820-860
13.	Total Sulphur, max		
	(a) For notified areas	% mass	0.25
	(b) For the rest	% mass	0.25
14.	Water content, max	% volume	0.05
15.	Cold filter plugging point (CFPP)		
	(a) Winter (Nov-Feb), max	°C	6
	(b) Summer, max	°C	18
16.	Total sediments, max	mg/100 mL	1.6

Annexure-II: BIS petrol specifications (IS 2796: 2000)

S. No.	Characteristics	Unit	Requirements	
			Unleaded regular	**Unleaded premium**
1.	Colour, Visual		Orange	Red
2.	Density @15°C	Kg/m^3	710-770	710-770
3.	Distillation:			
	(a) Recovery up to 70°C (E70)	% Volume	10-45	10-45
	(b) Recovery up to 100°C (E100)	% Volume	40-70	40-70
	(c) Recovery up to 180°C, (E180), min	% Volume	90	90
	(d) Final boiling point (FBP), max	°C	215	215
	(e) Residue, max	% Volume	2	2
4.	Research octane number (RON), min		88	93
5.	Anti-knock index (AKI), min		84	88
6.	Existent gum, max	g/m^3	40	40
7.	Potential gum, max	g/m^3	50	50
8.	Sulphur, total, max	% Mass		
	(a) For notified areas		0.05	0.05
	(b) For the rest		0.10	0.10
9.	Lead content (as Pb), max	g/L	0.013	0.013
10.	Reid vapour pressure (RVP), max	KPa	35-60	35-60
11.	Vapour lock index (VLI = 10 RVP + 7E70)			
	(a) Summer, max		750	750
	(b) Other months, max		950	950
12.	Benzene content, % vol. max			
	(a) For notified areas		1.0	1.0
	(b) For metros		3.0	3.0
	(c) For the rest		5.0	5.0
13.	Copper strip corrosion for 3 hrs @50°C, max	Rating	Not more than No. 1	Not more than No. 1
14.	Water tolerance of gasoline-alcohol blends, temp. for phase separation, °C max.			
	(a) Summer, max	°C	10	10
	(b) Winter, max	°C	0	0
15.	Engine intake system cleanliness	MFA used	To report	To report

Causes of fuel adulteration

Most developing country governments have not yet established a monitoring regime and system of fines that can act as a strong deterrent to fuel adulteration. There are number of reasons for this, including poor governance, a lack of political will, lack of public awareness, weak regulatory agencies and a shortage or even absence of technical staff and equipment for designing and conducting monitoring. Given these limitations, identifying and dealing with this abuse will require addressing problems on multiple fronts.

The primary factors encouraging the practice of adulteration are the following –

- Existence of differential tax levels amongst the base fuels, intermediate products and byproducts. The adulterants being taxed lower than the base fuels give monetary benefits when mixed with replacing a proportion of the base fuels.
- Differential pricing mechanism of fuels and adulterants and easy availability of adulterants in the market.
- Lack of monitoring and consumers awareness.
- Lack of transparency and uncontrolled regulations in the production-supply and marketing chain for intermediates and byproducts of refineries.
- Non-availability of mechanism and instruments for spot-checking the quality of fuels.

Adulteration and emissions

Fuel adulteration causes marked effect on the tailpipe emissions of vehicles, as adulterants alter the chemistry of the base fuel rendering its quality inferior to the required commensurate fuel quality for the vehicles. This in turn affects the combustion dynamics inside the combustion chamber of vehicles increasing the emissions of harmful pollutants significantly. In some cases effects of adulteration are indirect; for example, large scale diversion of rationed kerosene subsidized for household use to the diesel sector for mixing with diesel not only hamper engine performance of diesel vehicles, but also deprives the poor of kerosene which can otherwise be used for cooking and as a consequence of lack of availability of subsidized kerosene force the poor to continue to use biomass which expose them to high levels of indoor pollution. Adulterated fuel increases tailpipe emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter (PM). Air toxin emissions, which fall into the category of unregulated emissions, of primary concern are benzene and polyaromatic hydrocarbons (PAHs), both well known carcinogens. Kerosene is more difficult to burn than gasoline; its addition results in higher levels of HC, CO and PM emissions even from catalyst-equipped cars. The higher sulfur level of kerosene is another issue. The consequences to long term air pollution, quality of life and effect on health are simply ignored. Also ignored are the reduced life of vehicle engine and higher maintenance costs, particularly if the taxi, auto-rickshaw or truck is being rented for a daily fee.

Status of fuel adulteration in India[4]

As mentioned earlier adulteration of transport fuels at the point of sale and during transportation has become a routine problem in India. There are several petroleum products available in our country, which are close substitute of gasoline and diesel, but are available at considerable lower prices. The price differential is usually in the range of Rs. 35 to 40 in case of petrol and Rs. 15 to 17 in case of diesel. Since kerosene is usually considered as poor man's fuel, Govt. of India has been subsidizing it for public distribution for several years. It is common knowledge that significant portion of this subsidized kerosene is being diverted for adulterating gasoline. Several studies/survey carried out recently have together pointed out alarming rise in the cases of fuel adulteration in our country and some of them are as below –

- Tata Consultancy has conducted an extensive survey on the kerosene distribution pattern within the country. They arrived at the conclusion that more than 30% of Kerosene distribution intended for household consumption through PDS outlets flowed back to industry in one form or the other. This was a clear indication towards the flourishing business of adulteration in our country.
- According to Anti Adulteration Cell of India, Naphtha is a commonly used adulterant for gasoline. The modus operandi is to import the product in huge quantity and divert it for adulteration. In a major seizure a few days ago, the Cell detected import of naphtha through the Mangalore port allegedly for adulteration of auto fuels in Kerala, Andhra Pradesh, Karnataka, W. Bengal and M.P. The intention was to import and move the products to a factory in Pondicherry, where it got blended with other adulterant chemicals. Following the investigation, the Cell sealed 82 kL of naphtha, 31 kL of other products along with plant and machinery allegedly used for adulteration.
- Similarly a case of adulteration has also been reported from Uttar Pradesh in the city of Meerut, where an authorized transport company was caught with adulterated stock. This transport agency had the authority to transport both petrol & diesel to retail outlets and solvents for industrial use. The agency was supposedly using its workplace for adulterating diesel with kerosene.
- According to a news in "The Times of India", the State Government of Maharashtra loses a whopping Rs. 81 lakh and Rs. 75.6 lakh every month on account of combined sales & excise tax revenue against petrol and diesel adulteration in Mumbai city alone. This is believed to be 10 percent of the genuine sale, industry source reveal.
- Various estimates have been made of the extent of financial loss to the national exchequer as well as the oil companies as a result of diversion of PDS kerosene, use of off-spec, low value, hydrocarbons mixed with petrol and diesel, evasion of sales tax etc. Although these estimates vary over a wide range, it is safe to assume that the nation is losing at least Rs. 10,000 crores annually as a result of adulteration of fuel. If too this is added the social costs as a result of environmental pollution, damage to vehicles and other engines, etc., the loss could be substantially higher.
- With the plethora of foreign car manufacturers making a beeline to set up manufacturing facilities in the country, their first and immediate concern is the quality of petrol that gets supplied to the users' cars. They have uniformly found that supplies are heavily adulterated and particularly the Octane content is much lower than the specification value of 87%.
- Recently under the direction of the Supreme Court, Environment Pollution Control Authority (E PCA) through a local NGO (CSE) carried out tests of fuel samples from retails outlets and other points. The results of the study reveal 8.3% sample failure of the sample tested against 1-2 percent reported by oil companies in the past. The study further reveals that adulterated fuel in intelligent mix allowed retail outlets to reap a huge profit of more than Rs 25, 000 a day[18].

Approach for adulteration detection

A number of analytical techniques are available to detect adulteration. In all cases described below, it is important to have good sampling technique and access to a good petroleum analytical laboratory. For the majority of the tests, accurate data and analysis of original or uncontaminated fuel are also pre-requisite.

Table 1: Fuel properties needed for acceptable performance[19]

Fuel performance required	Combustion	Combustion	Combustion
Property controlled for gasoline	Octane number	Volatility	Volatility
	Distillation range	Vapor pressure	Vapor pressure
	Gravity	Contamination	Contamination
	Hydrocarbon composition	Copper corrosion	-----

Table 2: Fuel effects on spark ignition engines[19]

Performance problem	Fuel related cause
Excessive engine wear	High sulphur content
	Dirt contamination
Poor combustion	Inadequate octane number
	Heavy end contamination
	Performed gum impurities
Poor cold starting	Improper volatility controls
	Water contamination
Hot fuel problems	Improper volatility controls
Carburetor/Induction system fouling	Heavy end contamination
	High sulphur content
	Performed gum impurities
	Soluble metal contaminants
Filter plugging	Water contamination
	Dirt contamination
Spark plug fouling	High aromatic contents

Some of the approaches for detecting adulteration are outlined below –

(i) Full specification tests of the standards

This may be quite time consuming and many parameters may be well within the requirements even if the fuel is adulterated. In fact fuel standards or specifications are framed to ensure that the fuel corresponds to certain level of quality commensurate to technology requirements of the vehicles. Parameters in the fuel standards may not necessarily stand as checkpoint for any sort of fuel adulteration.

(ii) Testing selected parameters

This asks for testing some critical parameters, which are likely to be affected or altered by adulteration and adversely affect engine performance and emissions and can be evaluated. In general, many of the selected parameters may already be included in the full specification standards. However, dosage of multifunctional additive and cetane improver are intended for following the adulterants by dilution.

However, convenient methodology for determination at refinery and outlet levels are yet to be lined up in the country.

1. Density
2. Distillation
3. Hydrocarbon Composition
    - Aromatic, Vol. %
    - Olefins, Vol. %
    - Benzene, Vol. %
    - Sulphur, ppm
4. Stability
    - Existing gum
    - Potential gum
5. Octane Number
    - Research
    - Motor
6. Multifunctional additives-dosage

Impact of gasoline adulteration

Adulterating gasoline with kerosene causes increase in emissions, as kerosene is more difficult to burn than gasoline and this result in higher levels of HC, CO and PM. High sulphur contents of the kerosene can deactivate the catalyst and lower conversion of engine out pollutants. Kerosene addition may also cause fall in octane quality, which can lead to engine knocking. When gasoline is adulterated with diesel fuels, the same effects occur but usually at lower levels of added diesel fuel. Both diesel and kerosene added to gasoline will increase engine deposit formation.

The threat of fuel adulteration will not solve until the practical steps are not initiated at the grass root level. It is possible to improve the design parameters of engine used for transportation purpose. Studies reported in the used adulterated fuel, mainly kerosene, in gasoline or diesel. Blend indicates reduced performance both in engine and emission limits. The lab test shows that adulteration of gasoline with kerosene would reduce the life of the vehicle engines and also increase environmental problems.

CONCLUSION

Fuel adulterators are not just cheating consumers. The impure fuel is turning our cities to gas chambers reducing engine efficiency, weakening national productivity and dragging the economy down. Fuel adulteration causes marked effect on the tailpipe emissions of vehicles.

(i) Kerosene is more difficult to burn than gasoline and this result in higher levels of HC, CO and PM. High sulphur contents of the kerosene can deactivate the catalyst and lowers the conversion of engine out pollutants.

(ii) Adulterants alter the chemistry of the base fuel rendering its quality inferior to the required commensurate fuel quality for the vehicles. This in turn affects the combustion dynamics inside the combustion chamber of vehicles increasing the emissions of harmful pollutants significantly.

(iii) Adulteration increases emission of harmful pollutants from vehicles & worsening urban air pollution that would cause adverse effect on human health. Also Adulteration increases tail-pipe emissions of hazardous pollutants causing air borne diseases & green house gases.

(iv) Diversion of PDS kerosene for doping in Gasoline is mainly observed in auto rickshaws and trucks for monitory gains by their drivers or owners. Along with loss of government revenue, environmental impacts due to continuous worsening of air quality is at alarming level.

(v) The transportation sector is a major source of air pollution. It contributes to harmful exhaust emissions, such as green house gases, CO, oxides of sulphur and nitrogen, unburned hydrocarbons and SPM emissions.

(vi) Air pollution caused by Adulterated fuel emissions, especially NO_x, CO, unburned hydrocarbons (HC), and SPM has been a noteworthy matter. Concentration of lethal pollutants such as "BTEX" is increasing exponentially.

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