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Determination of the Variation of Physical Properties between Pure and Adulteration Component of Petroleum Products

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Abstract

Since beginning of the industrial revolution, the air pollution has been enhanced due to fast increasing use of fossil fuels. The automobile sector has emerged as a major consumer of fuel oil and a major contribution to air pollution. Adulteration of fuel at point of sale and during transportation has become an acute problem in country. An experimental study has evaluated the effect of blending adulterant like kerosene, turpentine oil, hexane, ethyl alcohol, toluene etc. The test was carried out in this research work were done in order to determine the variation of physical properties (density, certain index and distillation rate) between pure and adulteration component of petroleum products.

Keywords: Diesel; Petrol; Kerosene; Turpentine oil; Ethyl alcohol; Hexane; Automatic Distillation Unit; Hydrometer

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Introduction

Petroleum is a mixture of hydrocarbons that exist as a liquid in nature underground reservoirs and remain liquid at room temperature. When brought to the surface it is produced from processing of liquid hydrocarbons at natural gas processing plant and it includes both crude oil and petroleum product. 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 wide spread pollution in environment [1-3]. The adulteration of petroleum product is normally indulged primary due to significant price differential between products to alter and degrade the quality of fuel, it is act perpetrated daily by Unscrupulous [4]. People in developing countries with intention to exploit the situation for illegal profit. Illegal practice in the retail business is a global phenomenon and fuel adulteration is one of major abuse along with under dispersing product to customers [5]. Normal hexane (n- hexane) is both an anthropogenic and naturally occurring chemical. Hexane is a minor constituent of crude oil and natural gas. Its inclusion in variety of petroleum product is a consequence of refining operation that separate hydrocarbon with in specific ranges of boiling for such uses as heating oil or automotive fuels. Virtually all hexane is obtained from petroleum mixture through controlled fractional distillation and other refinery-based process [6].

According to DPR (Directorate of petroleum resources in Nigeria) - "Adulteration is act of weakening or contaminating the substance by adding another substance of low value to it, mixing of adulterant into fuels exist in various forms and both the type and quantity of adulterant vary from place to place. Moreover profitability, availability, blend availability is prominent factor, governing the choice of adulterants. Transport fuel (gasoline, diesel) are often adulterated with other cheaper product or byproduct, other waste hydrocarbon stream for mandatory gains [7,8]. Adulteration of automobile fuel lead to increase in the emission of Carbon monoxide, oxides of nitrogen and other emission of toxic substances, and consequent ill effects on public health [9]. In Indian context the gasoline and diesel is adulterated by mixing it with kerosene because it is difficult to distinguish by automobile user. The expected adulteration percentage is 10% to 30% by volume. In both cases less than 10% adulteration is financially unattractive, while more than 30% adulterations is likely to be easily detected by the user from the degradation of engine performance caused by adulterated fuel. Gasoline, Kerosene, Diesel are mainly composed of complex mixture of homologous series of hydrocarbons obtained from petroleum refining. Gasoline is light crude oil product containing hydrocarbon distribution from C_4 and C_{12} carbon atoms. Kerosene contains hydrocarbon from C_8-C_{18} carbon atom, whereas diesel is much heavier and is comprised of hydrocarbons with C_8-C_{40} carbon atoms [10]. Kerosene shortage has been major cause of

kerosene adulteration which has forced consumers the use of other alternative hydrocarbon substance which has also led to deforestation, generation of large quantity of carbon monoxide and other depleting substance. It has also put pressure on domestic gas demand thus forcing the price of cooking gas upwards [11]. Density and Distillation are some of physical parameters used to monitor the quality of diesel and ensure appropriate burning in the engine. The quantitative detection was done by using Automatic Distillation unit and Density [12].

Automatic Distillation unit

This method performs high-precision atmospheric distillation of petroleum products to determine quantitatively boiling range characteristics of petrochemical products such as natural gasoline, automotive spark ignition engine fuels, diesel fuels, petroleum spirits, kerosene etc.

Hydrometer

Laboratory determination of density of petroleum products normally handled as liquids using a glass hydrometer.

Materials and Methods

Materials

Highly pure Petroleum products (Diesel, Kerosene, Gasoline), obtained from the Anton Paar prove tec were used and for adulteration, different solvents (Ethyl alcohol, Hexane) was collected from market of Merck and turpentine brought form market of brand (Anand Organics). The laboratory work was carried out at the chemistry division of Forensic science laboratory, Lucknow and was carried out by using instrument Automatic Distillation unit of Antonpaar (ADU).

Method

For determination of density change and distillation, different concentration of diesel and gasoline samples were collected and Adulterated with different adulterants while storing it in appropriate bottles, sealed and kept at room temperature until testing. All the samples were submitted to two physical tests following the methods and the results were used for statistical treatment. Hydrometer for calculating density, ADU for calculating Distillation temperature of IBP (Initial Boiling Point), 10%, 20%, 50%, 80%, 85%, 90%, 95%. FBP (Final Boiling Point) were used.

Procedure for sampling in instruments

For distillation procedure 100 ml petroleum product (Diesel, Kerosene, and Gasoline) and adulterated mixtures were transferred to a specific distillation flask equipped with a thermocouple sensor and heated. In it sample is evaporated, condensed and distilled under controlled conditions according to the slandered. And observation was made of the percentage recovered at specific temperature. For determination of density of the sample was taken in the 100 ml measuring cylinder and hydrometer was placed in it and the observed reading was recorded.

Results

Adulteration of diesel with Kerosene oil

Adulteration of diesel with kerosene alters the density and distillation rate. **Figure 1a** depicts that as more kerosene oil is being added to diesel, more the density decreases**. Figure 1b** depicts that as the diesel volume % is decrease there is gradual decrement in temperature at every recovered volume % except at IBP i.e., up to 70% adulteration of diesel IBP increases and after it falls down **(Table 1).**

Adulteration of Diesel with turpentine

Figure 2a depicts that as the turpentine adulteration increase in diesel density gets decreases and at 50% diesel volume turpentine regains its density. **Figure 2b** depicts that more the turpentine% added there is gradual decrement in temperature at every recovered volume % except IBP i.e., up to 80% adulteration of diesel IBP increases and after it falls down **(Table 2).**

Adulteration of Petrol with kerosene oil

Figure 3a depicts the gradual increment of density as the volume of petrol decreases. **Figure 3b** depicts that as the petrol volume

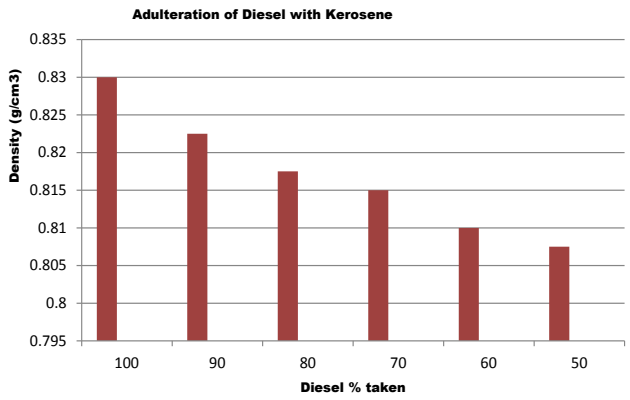
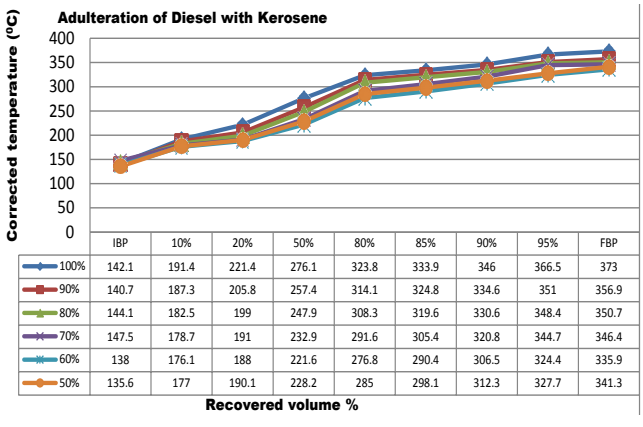


Figure 1a Adulteration of Diesel with Kerosene (Density vs. Percentage).



	IBP	10%	20%	50%	80%	85%	90%	95%	FBP
100%	142.1	191.4	221.4	276.1	323.8	333.9	346	366.5	373
90%	140.7	187.3	205.8	257.4	314.1	324.8	334.6	351	356.9
80%	144.1	182.5	199	247.9	308.3	319.6	330.6	348.4	350.7
70%	147.5	178.7	191	232.9	291.6	305.4	320.8	344.7	346.4
60%	138	176.1	188	221.6	276.8	290.4	306.5	324.4	335.9
50%	135.6	177	190.1	228.2	285	298.1	312.3	327.7	341.3

Figure 1b Adulteration of Diesel with Kerosene (Corrected temperature vs. Recovered volume (%).

Table 1 Adulteration of diesel with kerosene oil.

Diesel %	Density (g/cm³)
100	0.8300
90	0.8225
80	0.8175
70	0.8150
60	0.8100
50	0.8075

Table 2 Adulteration of diesel with turpentine.

Diesel %	Density (g/cm³)
100	0.8300
90	0.8200
80	0.8155
70	0.8125
60	0.7925
50	0.7900

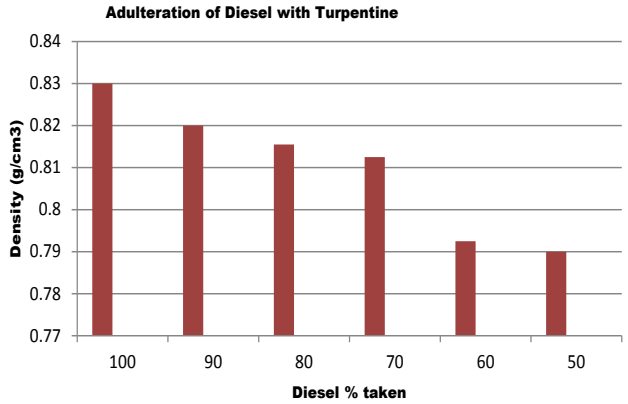


Figure 2a Adulteration of diesel with Turpentine (Density vs. Percentage).

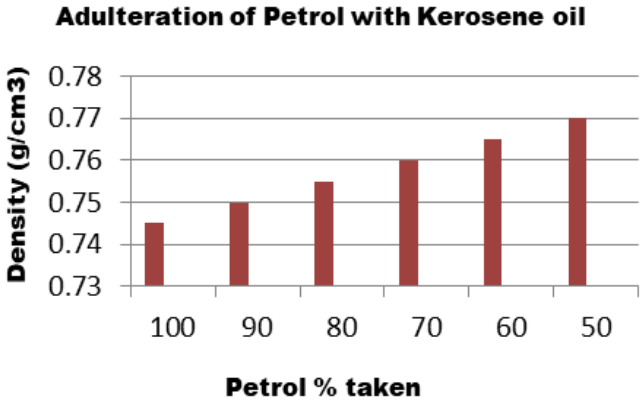


Figure 3a Adulteration of Petrol with Kerosene oil (Density vs. Percentage).

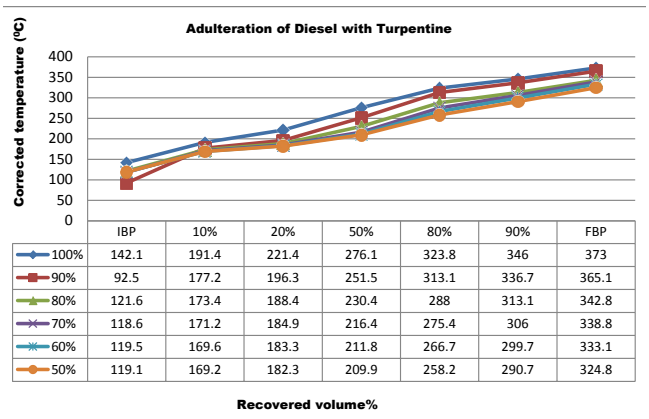


Figure 2b Adulteration of diesel with Turpentine (Corrected Temperature vs. Recovered volume (%).

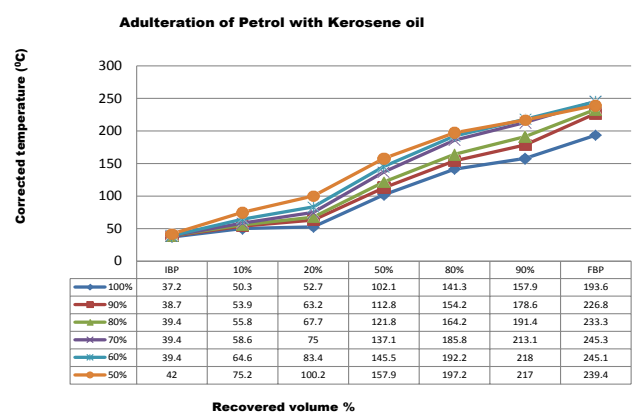


Figure 3b Adulteration of Petrol with Kerosene oil (Corrected Temperature vs. Recovered volume (%).

% decreases the temperature at recovered volume % increases but at IBP temperature it gets constant for 80% 70% 60% diesel volume **(Table 3).**

Adulteration of petrol with ethyl alcohol

Figure 4a shows very little variation in density change that is up to 95% adulteration density remains unchanged and after a little increment from 90% and 85% it again becomes constant which shows that only at 90% 85% adulteration density is changing. **Figure 4b** depicts that as the petrol volume % decreasing there is very minute variation seen in temperature for every recovered volume % but for 50% recovered volume temperature remains always constant **(Table 4).**.

Table 3 Adulteration of petrol with kerosene oil.

Petrol%	Density (g/cm³)
100	0.745
90	0.7500
80	0.7550
70	0.7600
60	0.7650
50	0.7700

Adulteration of petrol with Hexane

Figure 5a shows that density uniformly decreasing with decrease in petrol volume %, but from **Figure 5b** not such variation is

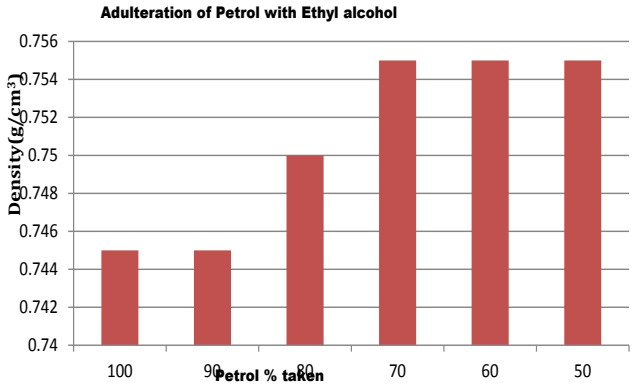


Figure 4a Adulteration of Petrol with Ethyl Alcohol (Density vs. Percentage).

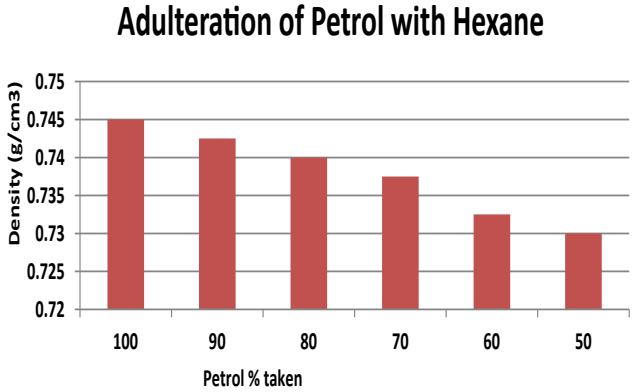


Figure 5a Adulteration of Petrol with Hexane (Density vs. Percentage).

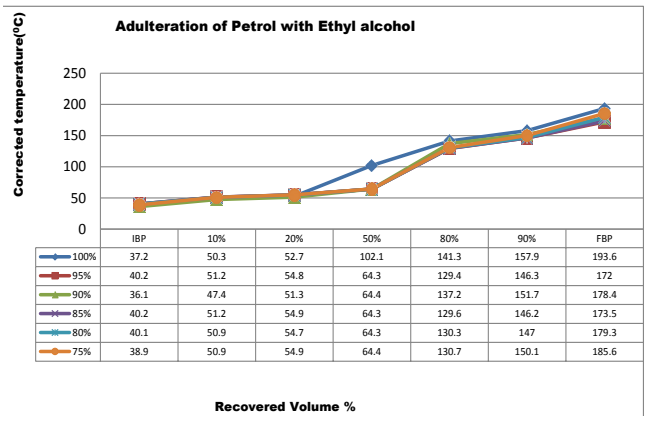


Figure 4b Adulteration of Petrol with Ethyl Alcohol (Corrected Temperature vs. Recovered volume (%).

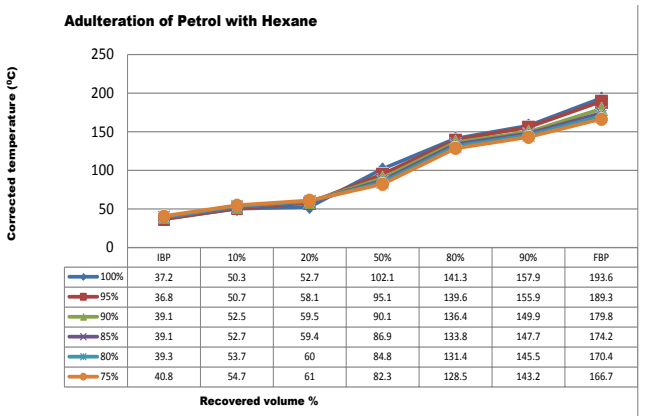


Figure 5b Adulteration of Petrol with Hexane (Corrected Temperature vs. Recovered volume (%).

Table 4 Adulteration of petrol with ethyl alcohol.

Petrol %	Density (g/cm³)
100	0.7450
95	0.7450
90	0.7500
85	0.7550
80	0.7550
75	0.7550

Table 5 Adulteration of petrol with hexane.

Petrol %	Density (g/cm³)
100	0.7450
95	0.7425
90	0.7400
85	0.7375
80	0.7325
75	0.7300

shown as the petrol volume % decreases except FBP, also at 90% adulteration petrol shows highest distillation rate **(Table 5).**

Adulteration of petrol with mixture

Figure 6a shows the density change only at 90% and 85% of petrol volume and from **Figure 6b** as the petrol volume% decreases; variation in temperature is only shown at recovered volume from 10% to 80% **(Table 6).**

Discussion

By comprising with the result of density and distillation profile from reference sample. It is found that for adulterating diesel density increase in case of turpentine and decrease in case of kerosene oil while distillating adulterated diesel at its different volume concentration the only variation shown is at IBP which first increases and then decreases. In petrol adulteration the different adulterants used are kerosene oil, ethyl alcohol, Hexane and mixture, all are increasing the petrol density, as more and more the volume % of these adulterants are increasing but in case of ethyl alcohol at 95%, 80%, 75% of adulteration it is quite difficult to detect its adulteration because density is unchanged at these concentration as shown in **Figures 7a and 7b**, while distilling adulterated petrol at its different volume concentration the distillation rate is varying as the adulterants in petrol is increasing **(Table 7).**

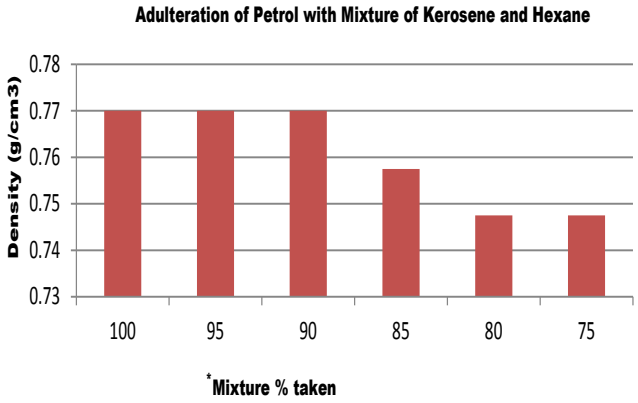


Figure 6a Adulteration of Petrol with Hexane and Kerosene Mixture (Density vs. Percentage).

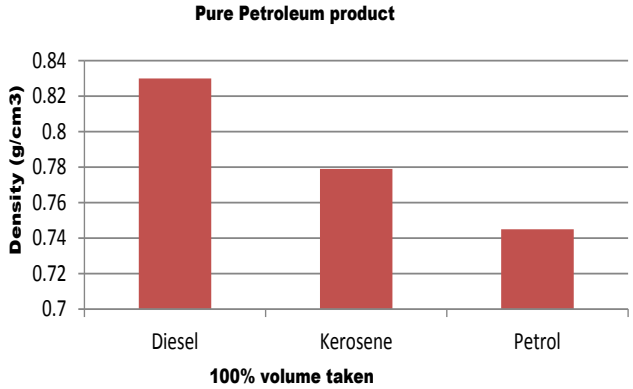
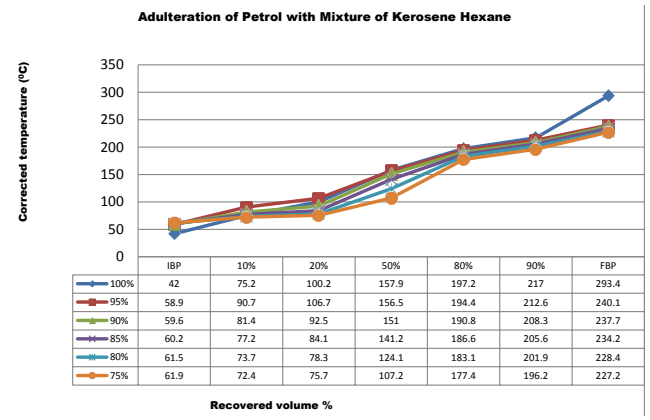
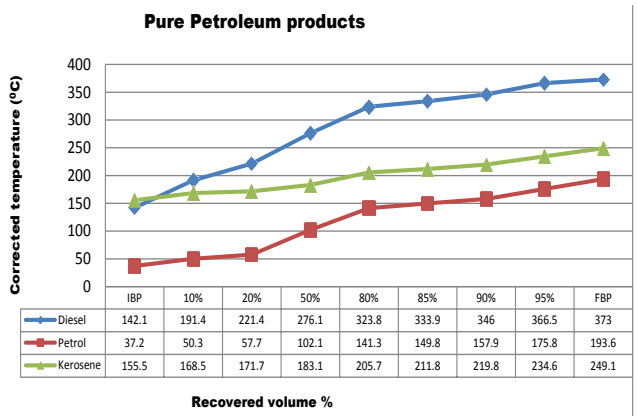


Figure 7a Pure Petroleum Products (Density vs. Percentage).



	IBP	10%	20%	50%	80%	90%	FBP
100%	42	75.2	100.2	157.9	197.2	217	293.4
95%	58.9	90.7	106.7	156.5	194.4	212.6	240.1
90%	59.6	81.4	92.5	151	190.8	208.3	237.7
85%	60.2	77.2	84.1	141.2	186.6	205.6	234.2
80%	61.5	73.7	78.3	124.1	183.1	201.9	228.4
75%	61.9	72.4	75.7	107.2	177.4	196.2	227.2

Figure 6b Adulteration of Petrol with Hexane and Kerosene Mixture (Corrected Temperature vs. Recovered volume (%).



	IBP	10%	20%	50%	80%	85%	90%	95%	FBP
Diesel	142.1	191.4	221.4	276.1	323.8	333.9	346	366.5	373
Petrol	37.2	50.3	57.7	102.1	141.3	149.8	157.9	175.8	193.6
Kerosene	155.5	168.5	171.7	183.1	205.7	211.8	219.8	234.6	249.1

Figure 7b Pure Petroleum Products (Corrected Temperature vs. Recovered volume (%).

Table 6 Adulteration of petrol with mixture of kerosene and hexane.

*Mixture %	Density (g/cm³)
100	0.7700
95	0.7700
90	0.7700
85	0.7575
80	0.7475
75	0.7475

Table 7 Experimental data of pure components.

Petroleum Products	Density (g/cm³)
Diesel	0.8300
Petrol	0.7450
Kerosene	0.7790

Conclusion

Fuel adulterants are not only cheating consumers but these impure fuels are turning our cities to gas chamber which weakens national productivity, reduces engine efficiency. Blending or mixing of adulterants into base transport fuels exists in various forms and both type and quantity of adulterants vary from place to place. This research shows that most of petroleum products from area under study are adulterated with low grade or partially refined petroleum products; this act is capable for altering the chemical and behavioral changes of petroleum products. From above experiment it concluded that adulteration in diesel can be easily detectable in both cases by calculating density and distillation rate but in case of petrol, calculating density is not sufficient for detection of adulteration but from distillation rate we can find the clear differentiation between pure and adulterated one.

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