ACHARYA NARENDRA DEV COLLEGE
ELITE PROJECT- ANALYTICAL COMPARISON OF ROAD SPACE RATIONING (ODD - EVEN RULE)

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COMPLETE REPORT

ABSTRACT-In this project we have done the Analytical comparison of the road space rationing scheme (odd–even scheme) implemented in Delhi and other foreign cities of the world.

INTRODUCTION

"Road space rationing is a method of decreasing traffic congestion in a city by limiting the number of vehicles allowed in a certain area based on license plate numbers. This method is usually exercised during peak periods in heavily congested city centers."
The earliest known implementation of road space rationing took place in Rome, as carriages and carts pulled by horses created serious congestion problems in several Roman cities. In 45 B.C. Julius Caesar declared the center of Rome off-limits between 6 a.m. and 4 p.m. to all vehicles. After that, Road space rationing based on license numbers has been implemented permanently in cities such as Athens (1982), Santiago, Chile (1986 and extended 2001), México City (1989), Metro Manila (1995), São Paulo (1997), Bogotá, Colombia (1998), La Paz, Bolivia (2003), San José, Costa Rica, (2005) countrywide in Honduras (2008), and Quito, Ecuador (2010).
Temporary driving restrictions were imposed in cities such as Beijing, Paris, London, Italy, Milan ,New Delhi.

ODD-EVEN RULE IN DELHI The Odd-Even Policy was a 15-day scheme implemented by the government of Delhi to reduce the impact of the pollution in Delhi. During this scheme, the odd numbers car(number plate)were allowed to move freely on streets of Delhi on Odd days and on even days , even car numbers were allowed from 8am to 8pm.

REASONS FOR IMPLEMENTATION OF ODD-EVEN RULE IN DELHI

The Delhi government's decision to introduce road rationing is chiefly influenced by Beijing's employment of the same policy. But in Delhi, the implementation of the odd-even car scheme was criticized. The move was expected to impact an estimated 8.4 million vehicles registered in Delhi.

Violators in Delhi would be fined Rs. 2,000. Delhi's air quality was in an emergency state. Air in Delhi has PM2.5 concentrations of 153 micrograms and PM10 concentrations of 286 micrograms-Way beyond the permissible limits. The degraded air quality in Delhi of that time was an imminent threat to its residents and their health. The air that Delhi breathes in is poisonous enough to cause chronic diseases such as asthma, bronchitis, breathing

disorders, lung cancer, skin related diseases etc. Around 3,000 people died on account of air pollution in Delhi.
There is a need to limit the quantum of vehicles and trim down pollution levels in the city so that its residents can lead a healthy life.

ANALYTICAL COMPARISION OF ROAD SPACE RATIONING IN DELHI AND OTHER FOREIGN CITIES

Paris

Paris is a beautiful example of how road rationing can actually work. On March 17th, 2014, a driving restriction was imposed in Paris and its suburbs based on license plate numbers. Very similar to what Delhi had imposed. The issue was raised by the city government to control the air pollution attributed to vehicle emissions. Cars with even number plates were banned from entering the city between 5:30 am until midnight.

It must also be added that the week before the traffic restriction was imposed, the government also reduced speed limits around Paris by 20km per hour and provided all public transportation for free to encourage one and all to use it. Violators would be fined 22 Euros (₹1641.02). This wasn't the first time they did this though. Paris tried this once before in 1997.

BEIJING

On July 20, 2008, Beijing implemented a temporary road space rationing policy, odd-even rationing policy, by allowing cars that have an even number of their license plates could drive on roads on one day while the cars that have an odd last number of their license plates could go on the road the next day in order to improve air quality in the city during the 2008 Summer Olympics. This policy did not affect taxis, public buses, yellow-plate vehicles (vehicles with more than 9 seats inclusive), police vehicles and military vehicles. Temporary driving restrictions were imposed in Beijing from December 8 to 10, 2015, as part of the smog mitigation measures provided by Beijing's red alert due to hazardous smog, the first such alert issued ever. A second red alert for pollution was issued on December 18, 2015.

Again, temporary driving restrictions were imposed for four days, beginning at 7 a.m. on December 19th and ending on the 23rd at midnight.

According to a third-party test, the policies issued were great in reducing the car emissions: a 40% daily reduction of vehicle emissions was reported after the following policy was carried out. Also, according to a professor in the Beijing University of Technology, the End-number License Plate Policy has reduced the number of cars on the public road-space of Beijing by 700,000, but with the rapidly increasing number of cars purchased, the effects of the policy would be negated within three years.

MEXICO CITY, MEXICO

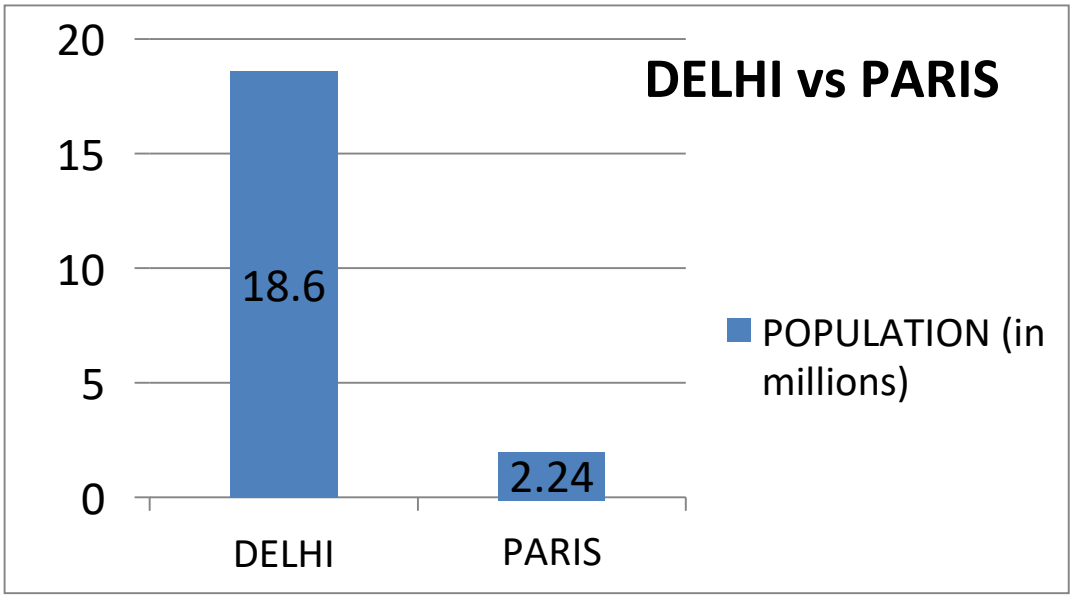
In the South American city of Mexico, the odd-even rationing policy or the Hoy No Circula (roughly and hilariously translating to 'today it doesn't circulate') was introduced as early as 1989. Cars would be banned for one day in the week depending on the number on their license plates. Violators were asked to pay anywhere between $23 to $69. Since they didn't have even half as many cars back then as Delhi has currently, they didn't have to do it the odd-even way. They would pick out numbers. For example Sundays, number plates ending with three and four were banned, Mondays five six, Tuesdays seven eight, so on and so forth.

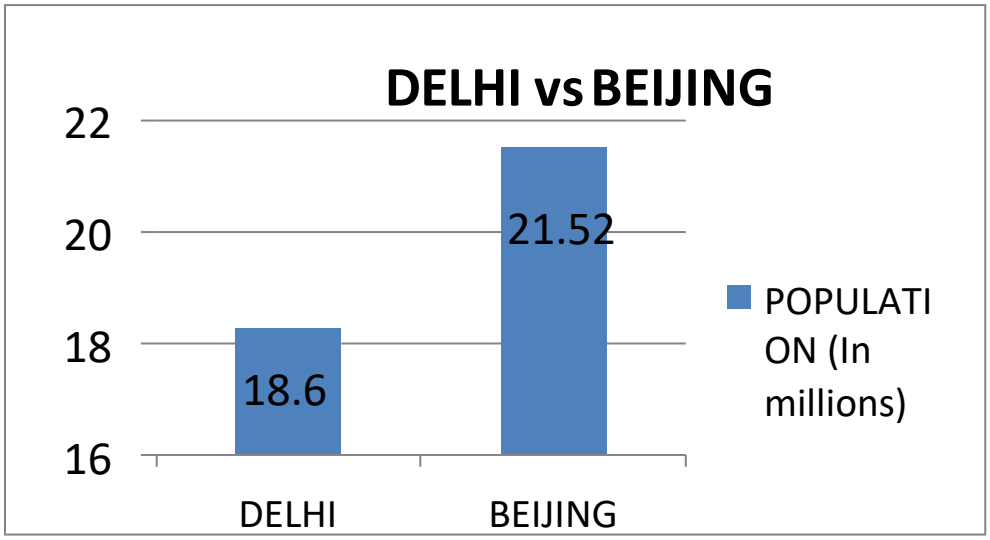
BOGOTA, COLOMBIA

The Columbian capital of Bogota also implemented the rule of Pico y Placa ('peak and plate') They just started banning cars during the peak hours for two days a week. They wanted their

citizens to take them seriously so they started fining the violators 15% of their daily minimum wages. To make sure people don't try to act like they did in Mexico and buy two cars, they started changing the combination of days and numbers every now and then.

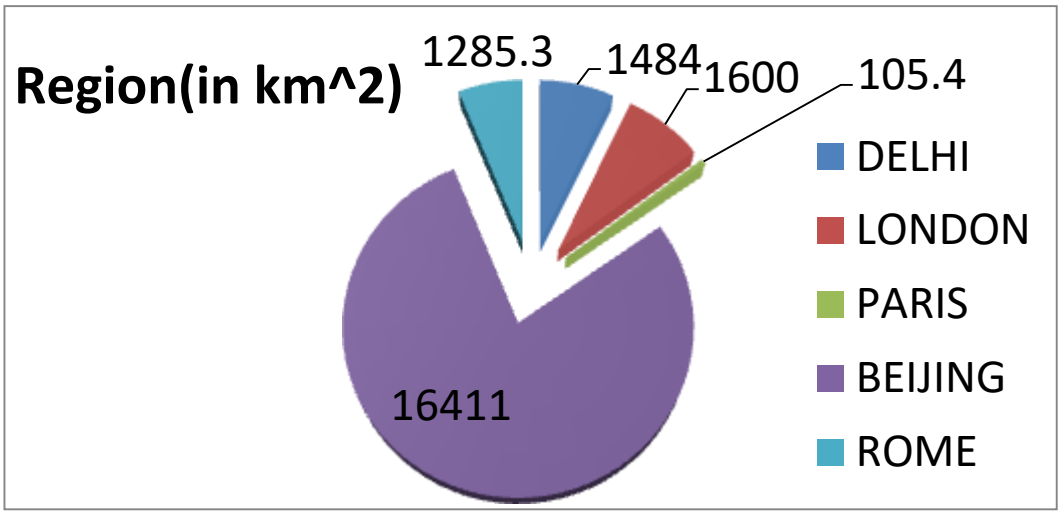
POPULATION



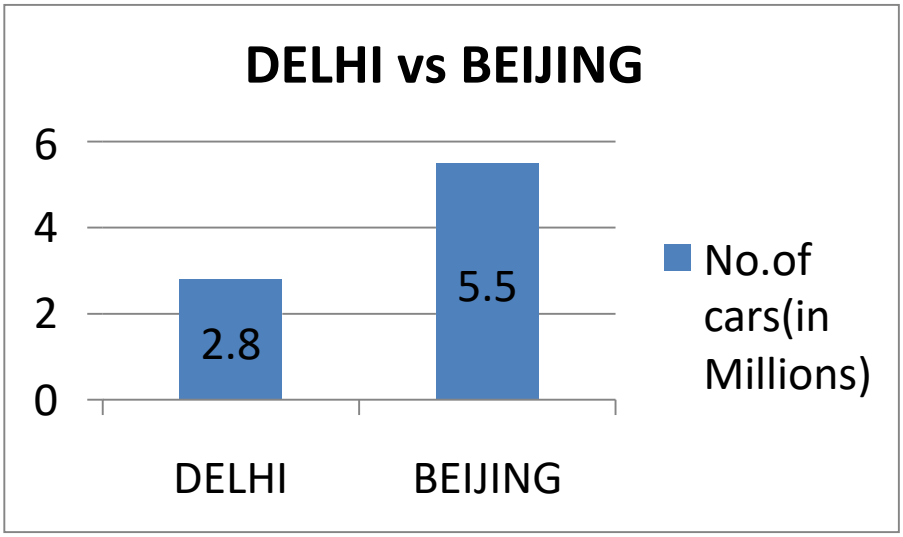


REGION

1. The restriction was implemented in Paris and 22 towns located in the administrative region of Île-de-France.
2. The restriction was implemented in whole Beijing city.
3. The restriction was implemented in London city during 2012 summer Olympics.



NUMBER OF CARS RUNNING ON ROAD



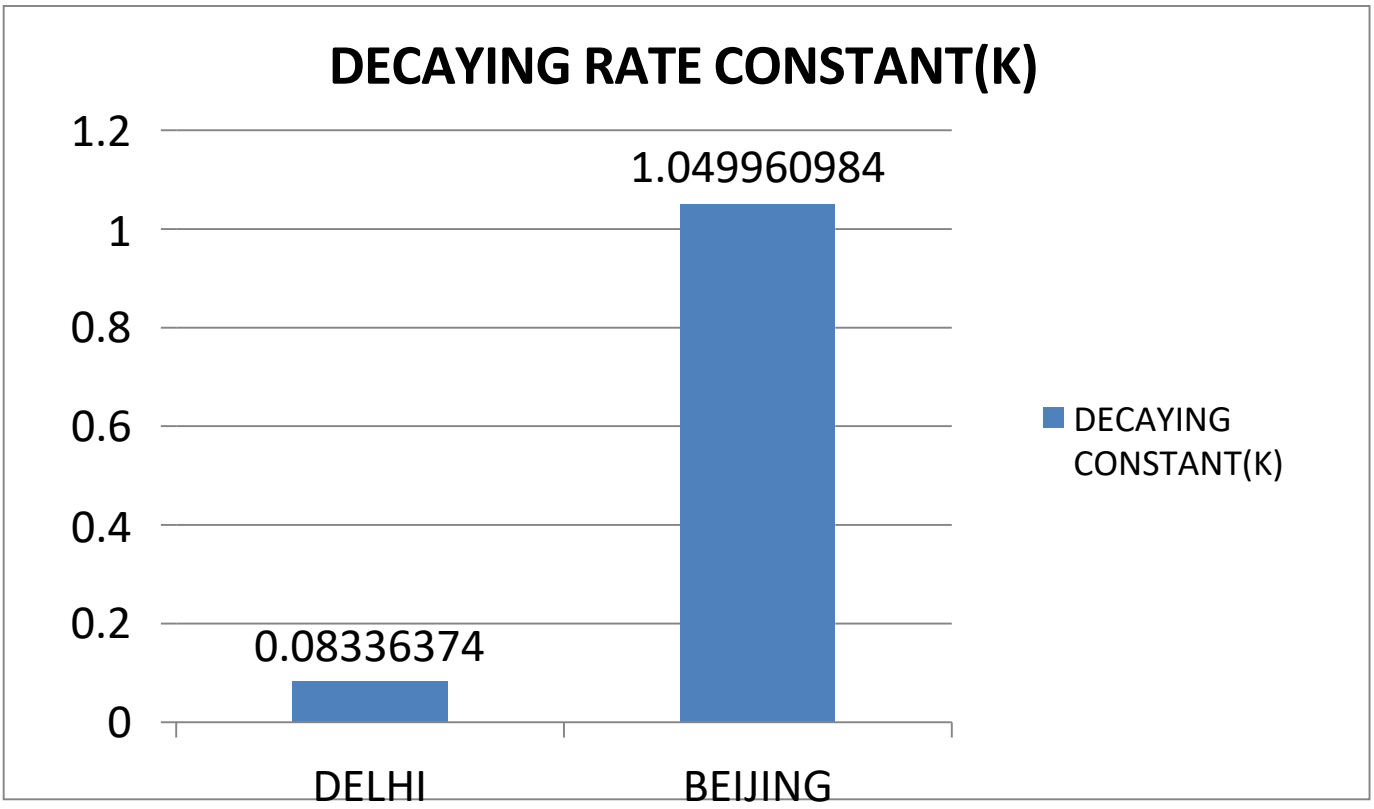
DECAYING RATE OF POLLUTION

Formula for decaying rate
N=N0*e^(-k*t)
where N=min. value of PM2.5 at day 1
N0= max. value of PM2.5 at last day
t= number of days
k=decaying rate constant

	N	N0	t	K
DELHI	124	433	15	0.0833637
BEIJING	15	350	3	1.0499609

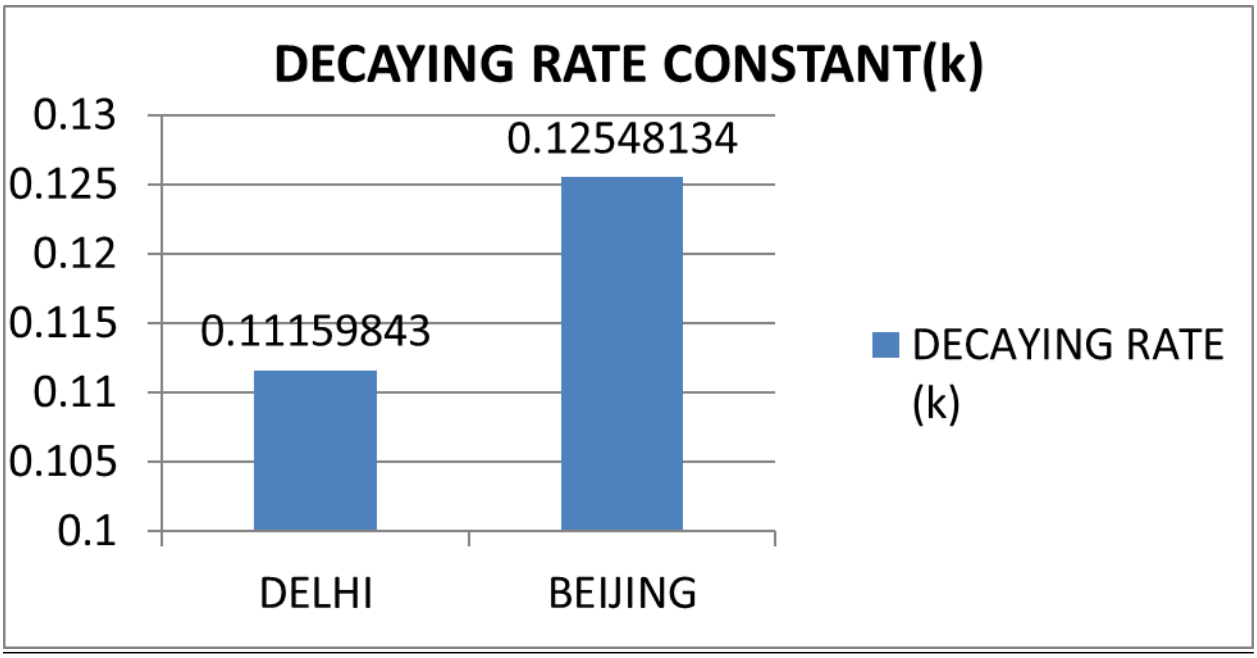
DELHI v/s BEIJING

PHASE 1(1-15 JANUARY 2016)



PHASE 2(15-30 APRIL 2016)

	N	N0	t	k
DELHI	48	256	15	0.1115984
BEIJING	158	261	4	0.1254813



By using the decay rate of last data, we calculate the number of days to get the normal level of air quality

N=Minimum safe level of AQI(PM2.5) in Delhi
N0=Current value of AQI(PM2.5) in Delhi

DELHI PHASE 1 AND PHASE 2:-

DELHI	N	N0	k	t(in days)
Phase1	60	168	0.0833434	12.35
Phase2	60	168	0.1115983	9.22

Since the pollution level of Delhi is fluctuating, so whatever the decaying rate is, we require Type equation here.nearly 13 days to reach at safe level of pollution and this scheme must be implemented after every 3 months.

T-Test

AIM:- To find the difference between the average pollution level of Delhi and Beijing.

We use the following formulas

$$t = \frac{x_1 - x_2}{\sigma\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$where \quad \sigma = \sqrt{\frac{n_1 {s_1}^2 + n_2 {s_2}^2}{n_1 + n_2}}$$

Degree of freedom, $v = n_1 + n_2 - 2$

	n		X		s^2	
	phase1	Phase 2	phase1	Phase 2	phase1	phase2
Delhi	15	15	293.095	103.259	8499.2858	2995.82647
Beijing	3	4	211.3331	243.917	6554.02207	3961.10445

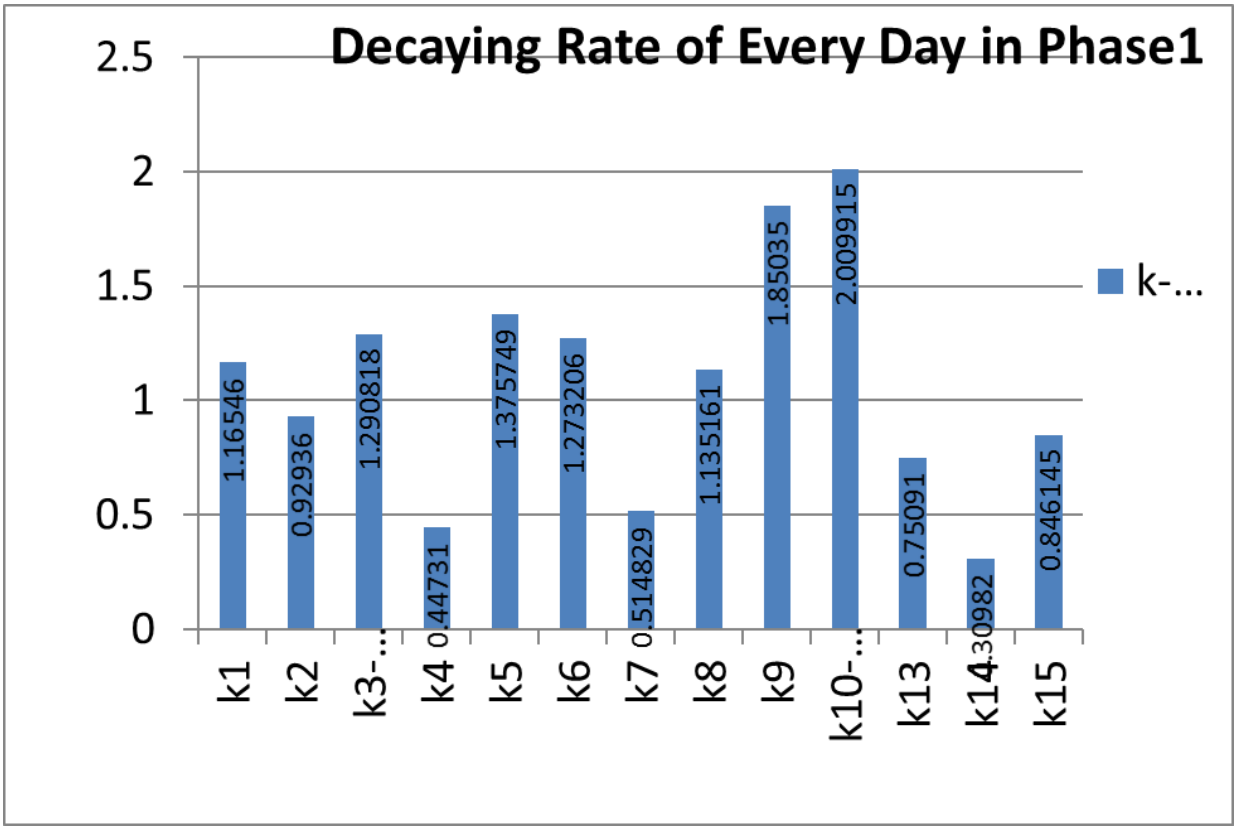
Pooled Standard Deviation $\sigma = 95.907804$(Phase 1),$\sigma = 59.7946559$(Phase 2)
From calculations , we get
Phase1, $1.348027747 < 1.746$($t_{.95,}$ when v =16)
Phase 2, $-4.180237177 < 1.740$($t_{.95,}$ when v=17)
Test verified.
CONCLUSION- There is no significant difference between the average pollution level of Delhi and Beijing

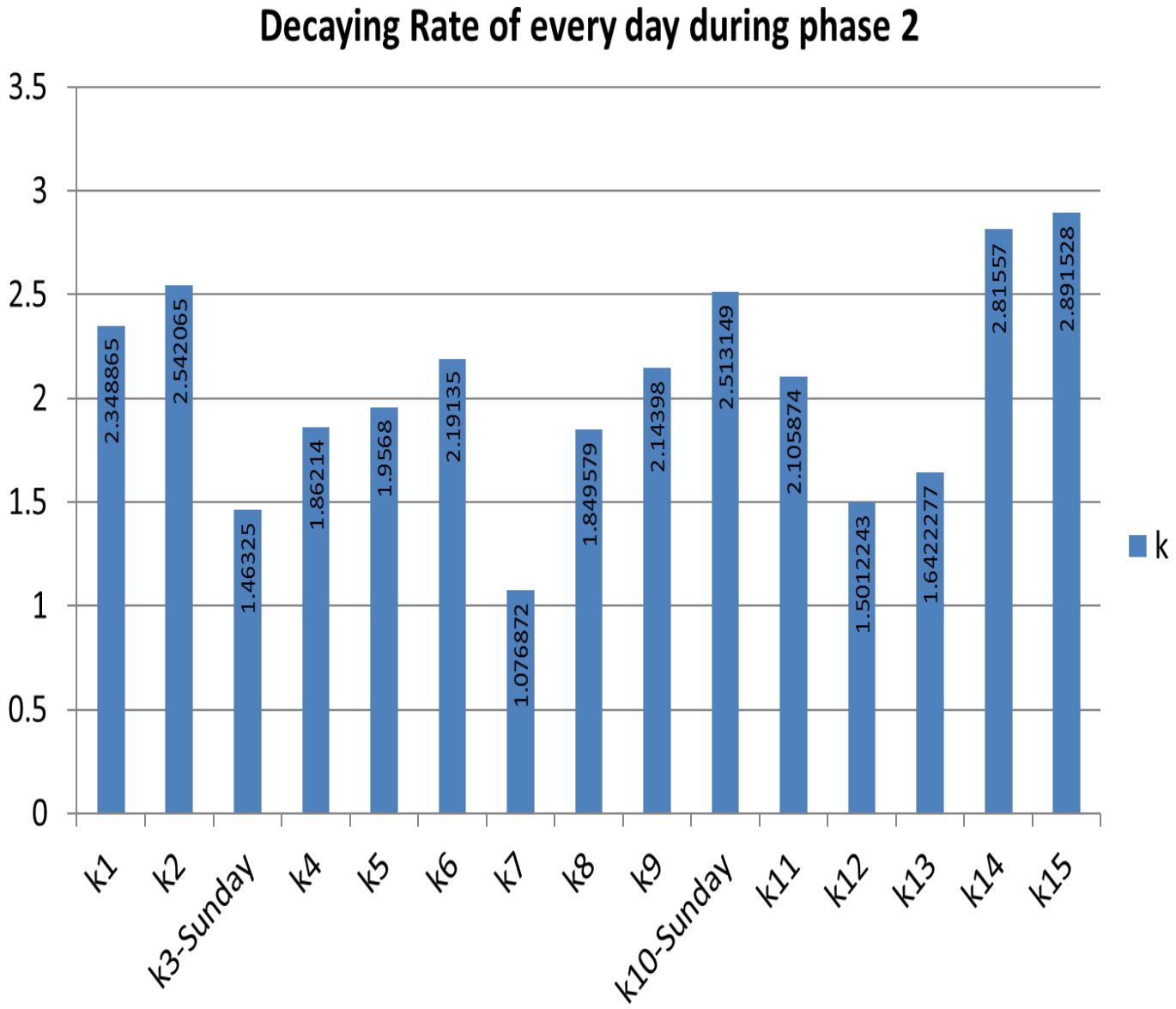
F-TEST

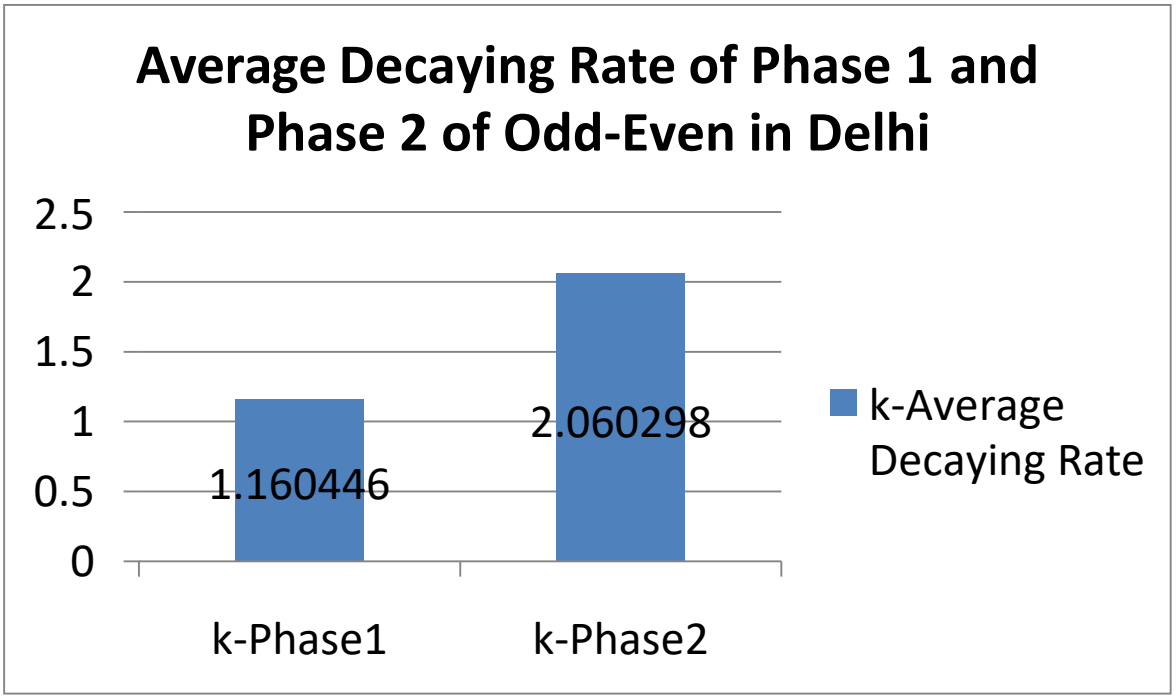
AIM – To find the difference between the variation of pollution level of Delhi and Beijing
Formula:- $F = (s1)^2/(s2)^2$
Degree of Freedom , $v_1 = n_1 - 1$
$v_2 = n_2 - 1$
If, $F_{0.05} < F < F_{0.95}$, then test is verified.
For Phase 1,
F=1.29680459
$-18.4 < 1.29680459 < 19.4$
For Phase 2,
F=0.7563410899
$-7.72 < 0.75631.8998 < 8.72$
Hence, Test verified.

CONCLUSION-There is no significant difference between the variation of Pollution level of Delhi and Beijing.

The above two results forced us to calculate the average decay rate of both phases of Delhi




Decaying Rate of every day during phase 2
3.5
3
2.5
2
1.5
1
0.5
0
2.348865
2.542065
1.46325
1.86214
1.9568
2.19135
1.076872
1.849579
2.14398
2.513149
2.105874
1.5012243
1.6422277
2.81557
2.891528
k1
k2
k3-Sunday
k4
k5
k6
k7
k8
k9
k10-Sunday
k11
k12
k13
k14
k15
k



This surprised us that the average decay rate of Delhi and Beijing was almost same.

Data of Delhi(Phase 1)

	PM2.5(inμg/m3)	**No. of vehicles(cars & trucks)**
DAY 1	307.625	59,373
DAY 2	239.7083	58,973
DAY 3	--Sunday--	--Sunday--
DAY4	411.166	3,15,673
DAY 5	356.478261	1,21,673

Data of Delhi(Phase 2)

	PM2.5(inμg/m3)	**No. of vehicles(cars &trucks)**
DAY 1	93.666	2,17,673
DAY 2	89.166	1,73,473
DAY 3	--Sunday--	--Sunday--
DAY 4	53.7083	2,87,473
DAY 5	86.4583	1,13,073

CORRELATION

We calculated the correlation between number of vehicles running on road and the pollution level in Delhi.This is calculated for sketching the regression model which will suggest how many vehicles should be on the road to get control over pollution.

FORMULA USED-

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\,n\Sigma x^2 - (\Sigma x)^2\,]\,[\,n\Sigma y^2 - (\Sigma y)^2\,]}}$$

Correlation coefficient between number of vehicles and pollution level

- In phase 1= 0.86183331
- In phase 2= -0.70905872

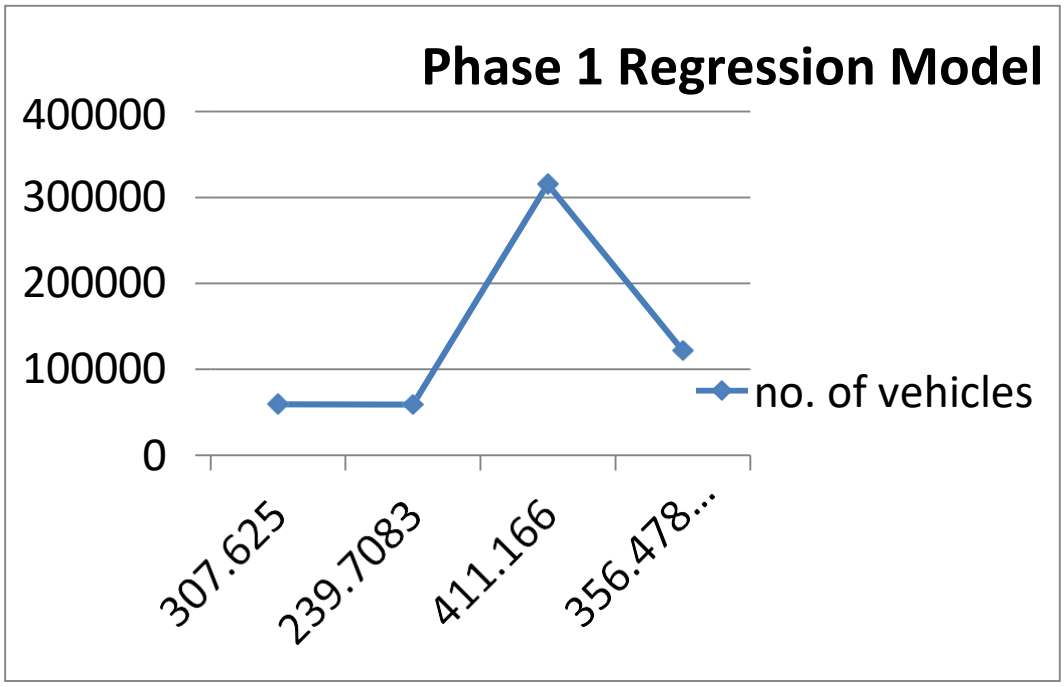
REGRESSION MODEL

$$\bar{y} = a\bar{x} + b$$

where,
a = [$\Sigma x_i y_i$ –(1/n) $\Sigma x_i y_i$]/[$\Sigma(x_i)$^2-(1/n)(Σx_i)^2]
X_i = Pollution level in Delhi
y_i = No. of vehicles running on road

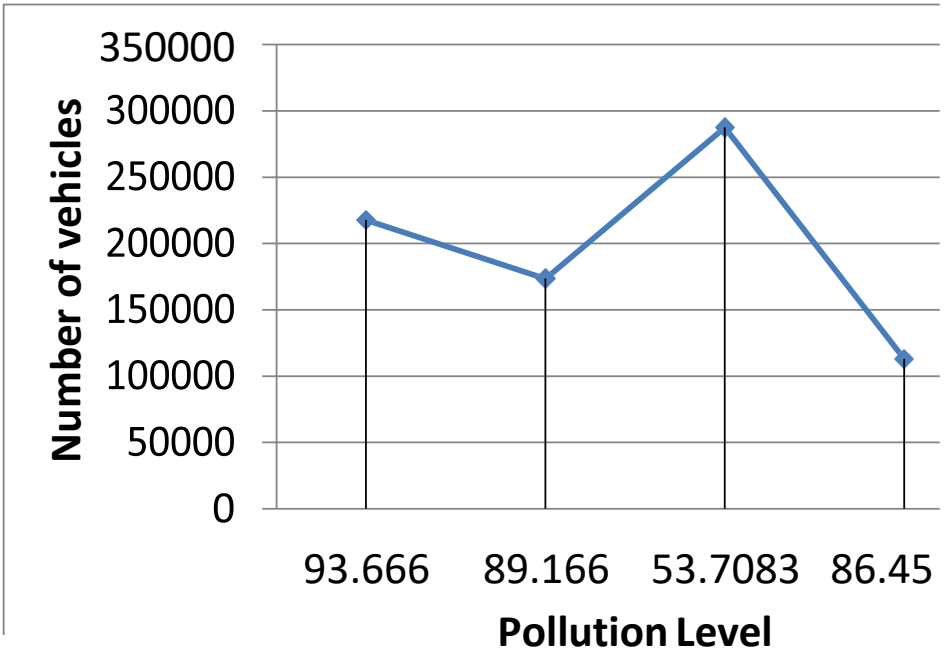
Phase 1- Model:-

$$\bar{y} = 1436.25562\bar{x} - 333237.978$$



Phase 2- Model:-

$$\bar{y} = 2852.36321\bar{x} - 32404.331$$



CONCLUSION-From the regression model of Phase1 and Phase2, we can see that there is no significant difference between number of vehicles and Pollution level.

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CONCLUSION

This rotational policy is the solution for Delhi . It is the need of the hour, to ensure sustainable development and growth . Strict implementation and sincere co-operation by the people is vital for this strategy to bear fruit and realise the desired outcomes.

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