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# SPATIAL AMBIENT AIR QUALITY ANALYSIS AND ITS EFFECTS ON THE TRAFFIC POLICE WITHIN THE CENTRAL BUSINESS DISTRICT IN NAIROBI, KENYA

By THOMAS OMWEGA

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# OBJECTIVES

**Main Objective.**

- To analyze spatial ambient air quality within the CBD in Nairobi and to determine its effects on the health of the traffic police officers.

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## OBJECTIVES CONT..

**Specific Objectives.**

- To determine automobile CO, $CO_2$ and $NO_x$ automobile emissions levels,
- To examine the effects of CO, $CO_2$ & $NO_x$ on the health of the TPO's
- To suggest measures to prevent the negative effects of poor air quality within the CBD in Nairobi.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| EMCA 1999 | Environmental Management and Coordination Act, 1999 |
| KNBS | Kenya National Bureau of Statistics |
| MOH | Ministry of Health |
| OEL - CL | Occupation Exposure Limit – Control Limit |
| OSHA 2007 | Occupational Safety and Health Act 2007, |
| ROK | Republic of Kenya |
| TPO | Traffic Police Officer |

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## INTRODUCTION

**Background of the Study**

- In Kenya, every person is entitled to a clean and healthy environment
- WHO contents that clean air is a basic requirement for human health and well-being (WHO, 2002)
- KEMRI reported that cancer among the urban between the periods 2000 to 2002 was in an upward trend (Korir *et al.*, 2008),

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- Data from MOH indicate that malaria leading cause of morbidity followed closely by diseases of respiratory infections in the year 2005, 2006 and 2007 respectively. Both diseases have been cited as contributing to more than 50% of the burden of the disease in total outpatient cases (MOH, 2008)

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## TRAFFIC POLICE OFFICERS (TPO'S)

- Traffic department- a department within the Kenya Police force that is charged with ensuring that drivers on the road comply with the traffic Act and related subsidiary legislations.

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## REGISTRATION OF MOTOR VEHICLES

- Data from KNBS indicate that there has been a consistent increase in the number of vehicles registered coupled with an increase of consumption of petroleum products (KNBS, 2009). This data together with Session paper No 4 of 2004 (ROK, 2004), reveal that there has been a rapid growing number of second hand cars,

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## TRAFFIC IN ONE OF THE STREETS IN NAIROBI

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## AUTOMOBILE EMISSIONS

- Vehicular emissions have been found to be the dominant source of air pollution especially in areas with high traffic densities. Reasons for high pollution emissions:-
  - Road congestion,
  - Poor fuel quality
  - Inadequate emissions controls,
  - Poor maintenance
  - High average age of the vehicle

Smoke

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## STATEMENT OF THE PROBLEM

- There are various legal frame works in Kenya such as EMCA 1999 and OSHA 2007 , the Traffic Act Cap. 403, that safe guard against the pollution of the environment,
  - Little research done to determine the levels of automobile emissions and specifically to investigate their effects on the general public,
  - Effect of air pollution on the health of traffic police staff in Kenya has hardly been assessed

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## SIGNIFICANCE OF THE STUDY

- Research will provide data on ATMAP
  - Identifying sources of ATMAP and their general emission levels.
  - Developing and implementing cost effective mitigation measures and monitoring regimes.
  - Provide information necessary for research, policy development and planning
  - Assist in decision making on the efficient management of the environment.
  - Raise concern on the health effects of automobile air pollutions to the TPO's and the public

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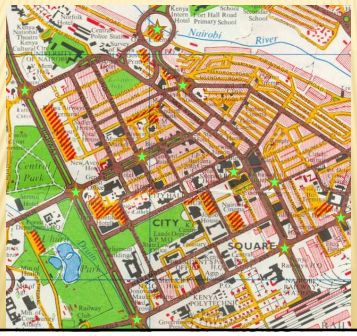
## SCOPE OF THE STUDY

- Air samplings were conducted at ten selected major sites within the CBD




Key:
☆ Sample Points

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## MATERIALS AND METHODS

### Study Design

- Conducted through cross sectional survey.
- The sample included TPO's who normally control traffic in Nairobi CBD

### Study Site

- The study was conducted in Nairobi the Capital City of Kenya. Samplings were carried out between December 2009 and March 2011.

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## CITY OF NAIROBI

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## POPULATION AND SAMPLING TECHNIQUES

- Target and Accessible Population
- Target population: Traffic police in Nairobi
- Accessible population: TPO's who operate within CBD
  i. Central police Station = 38 traffic officers **Female= 11,** Male = 27
  ii. Nairobi Area Police Station= 136 TPO's: **Female= 19,** Male =117

**This give a total of 174 TPO's**

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## DETERMINATION OF SAMPLE SIZE

$$n = \frac{Z^2 . p . q . N}{(N-1) . e^2 + Z^2 . p . q}$$

**n = 120** (Adopted from Kothari, 2004)

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## MATERIALS AND METHODS CONT..

- Determination of Sample Size

| Station | Population | | | Sample | | |
|---|---|---|---|---|---|---|
| | Total | F | M | M | F | Total |
| Central P.S | 38 | 11 | 27 | 19 | 7 | $n_1$=26 |
| Nairobi Area P. S | 136 | 19 | 117 | 81 | 13 | $n_2$=94 |
| Grant Total | 174 | 30 | 144 | 100 | 20 | n=120 |

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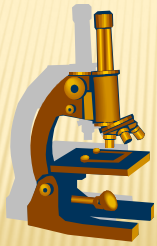
# DATA COLLECTION AND INSTRUMENTATION



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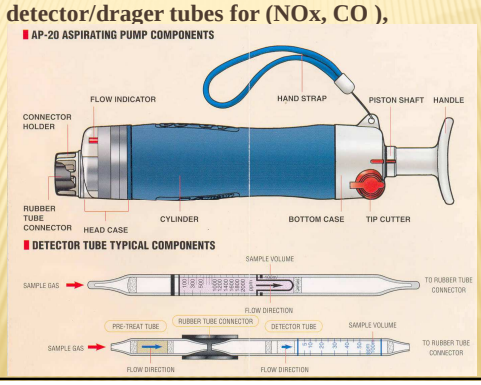
- **Instrumentation**
- **A gas Aspiration pump AP-20 together with detector/drager tubes for (NOx, CO ),**

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## Instrumentation cont…

- **Testo 435 multifunction measuring instrument was used to determine $CO_2$ levels, wind velocity and temperature.**

- **Questionnaires**

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## MATERIALS AND METHODS CONT..

### Data Analysis Methods

**Both descriptive and inferential statistics was used to analyze the data that was collected.**

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## MATERIALS AND METHODS CONT..

### Research Procedure

**Permission first obtained from relevant authorities to conduct the study .**

**The questionnaires were first pre- tested to determine their content validity by being given to a panel of experts namely *Prof. Zipporah Ng'ang'a and Dr. Ciira Kiiyukia both of ITROMID, JKUAT, Dr. Ruth Kahuthia – Gathu- KU: school of Enterprise Dev***

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## MATERIALS AND METHODS CONT..

$$CVR = \frac{n_{3/4} - N/2}{N/2}$$

**Adopted from Oso & Onen, 2005**

**CVR converted to content validity index (CVI) by obtaining the average of CVR**
**A CVI of 0.717 was achieved**
**CVI with a value of at least 0.70 is accepted as valid (Oso & Onen, 2005)**

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## DATA ANALYSIS METHODS

- Descriptive and inferential analysis was used to analyze the data
- Data was also represented in form of bar graphs, percentages and frequency tables
- Computer software SPSS package was used to assist in data analysis,
- All data analyzed at a level of 95% confidence

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## ETHICAL CONSIDERATIONS

- Participants not subjected to any risks
- The following explained
  - Purpose of the study,
  - Expected duration,
  - Benefits of the study to participants
- Confidentiality and privacy assured
- The participants were at liberty to ignore items in the questionnaire that they did not wish to respond to

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## RESULTS AND DISCUSSIONS

| Sampling Point | $CO_2$ (ppm) | CO (ppm) | $NO_x$ (ppm) | Temp (°C) | Wind Vel (m/s) |
|---|---|---|---|---|---|
| UWR | 622.25±32.94 | 12.26±0.32 | 2.44±0.26 | 26.90±1.63 | 1.65±0.20 |
| FSR 2 | 660.00±15.46 | 12.56±0.16 | 2.56±0.34 | 27.90±1.79 | 1.60±0.23 |
| HSR | 627.00±13.76 | 12.56±0.26 | 2.50±0.38 | 28.20±1.77 | 1.46±0.09 |
| NHR | 613.50±14.37 | 12.44±0.91 | 2.62±0.45 | 25.60±1.67 | 1.68±0.26 |
| GCR 3 | 655.50±25.57 | 13.60±0.69 | 3.02±0.69 | 28.40±1.78 | 1.59±0.19 |
| KBS | 646.25±33.02 | 13.63±0.46 | 3.02±0.97 | 26.90±2.24 | 1.29±0.18 |
| BBR 4 | 605.50±28.49 | 12.35±0.59 | 2.47±0.41 | 27.80±1.63 | 1.94±0.11 |
| JMK | 614.50±24.49 | 12.38±0.48 | 1.52±0.33 | 27.70±1.86 | 1.73±0.14 |
| JTR 1 | 675.25±21.20 | 12.56±0.81 | 2.47±0.34 | 31.80±1.86 | 1.58±0.20 |
| WMR | 628.25±22.04 | 13.05±0.42 | 3.02±0.26 | 25.30±1.68 | 1.61±0.20 |

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## RESULTS AND DISCUSSIONS CONT..

- $CO_2$ had a mean 634.80±23.13 ppm,
- CO had a mean 12.74±0.51 ppm
- $NO_x$ had a mean 2.56±0.44 ppm,
- Temp had a mean 27.65±1.80 °C
- Wind Vel had a mean 1.61±0.18 m/s

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## TEST OF HYPOTHESES

| Pollutant | Mean (ppm) | Null Hypothesis | Alternative Hypothesis |
|---|---|---|---|
| $CO_2$ | 634.80 | $H_o: \mu \leq 5000$ ppm | $H_a: \mu > 5000$ ppm |
| CO | 12.74 | $H_o: \mu \leq 50$ ppm | $H_a: \mu > 50$ ppm |
| $NO_X$ | 2.56 | $H_o: \mu \leq 3$ ppm | $H_a: \mu > 3$ ppm |

**The hypotheses were tested for the sampled pollutants applying '*t*'- test at 5% significant level.**

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## RESULTS: ANALYSIS USING *T* – TEST AT 5%

| Sample | Critical value of '*t*' *(One tailed)* | df | Rejection region *(One tailed)* | Calculated value of $\lvert t_c \rvert$ |
|---|---|---|---|---|
| $CO_2$ | 1.833 | 9 | R : $t > 1.833$ | 566.1 |
| CO | 1.833 | 9 | R : $t > 1.833$ | 219.9 |
| $NO_X$ | 1.833 | 9 | R : $t > 1.833$ | 3 |

**A statically significant difference between the $\bar{X}$ and μ. Reject $H_o$ and accept $H_a$ i.e automobile emission levels are above the OEL –CL (Long term)**

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## The results suggests that:

- The TPO's were exposed to levels above the OEL -RC and WHO values for CO (9 ppm for 8 hours TWA) and $NO_x$ (0.024 ppm annual meam).
- These findings were comparable with the findings of Atimtay *et al.*, (2000); Volpino *et al.*, (2004) and Jinsart *et al.*, (2002). Atimtay had reported in his study in Ankara, Turkey that the TP were under risk due to their inhalation of CO rich air while on duty.





- Volpino *et al.*, (2004)-Rome, Italy reported that chronic occupational exposure to urban pollutants of TPO's reduces resistance to physical effort and increased risk of cardiovascular and respiratory changes including slight hypoxemia,
- Jinsart *et al.*, (2002), reported in Bangkok, Thailand that TPO's who were exposed to high levels of automobile derived particulate air pollution showed higher prevalence of respiratory disorders





## Determination of Pearson's Coefficient of Correlation

| Sample | N | $r_{xy}$ (Temp) | $r_{xy}$ (Wind vel) |
|---|---|---|---|
| $CO_2$ | 10 | 0.511 | -0.745 |
| CO | 10 | -0.123 | -0.767 |
| $NO_x$ | 10 | -0.210 | -0.480 |

Moderate + $r_{xy}$ btn $CO_2$ with Temp, Weak - $r_{xy}$ btn CO, NOx with Temp. High degree of - $r_{xy}$ btn CO2, CO with wind vel, Moderate - $r_{xy}$ btn NOx with wind vel





## INFERENCE

- Temperature plays an important role in combustion.
- Highest concentrations of the pollutants were obtained when the wind speed were lower

These results compares well with the results that were obtained by Odhiambo *et al.*, (2010)

- NOx plays a key role in the formation of $O_3$ at elevated temperatures
- Production of more $CO_2$ and less CO is an indicator of improved combustion efficieny





## ANALYSIS OF QUESTIONNAIRE RESPONSES

The traffic police officers were asked to react to given statements on a questionnaire

- The percentage of male and female despondences are shown below.

| Sex | Frequency | Percentage |
|---|---|---|
| Male | 100 | 85.5 % |
| Female | 17 | 14.5 % |
| Total | 117 | 100 % |





## AGE OF TPO'S

| Age Bracket | Frequency | Percentage |
|---|---|---|
| 18 - 25 years | 9 | 7.7 % |
| 26 - 35 years | 71 | 60.7 % |
| 36 - 45 years | 35 | 29.9 % |
| 46 years and above | 2 | 1.7 % |
| Total | 117 | 100 % |

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## MARITAL STATUS

| Marital Status | Frequency | Percentage |
|---|---|---|
| Married | 101 | 86.3 % |
| Not Married | 16 | 13.7 % |
| Total | 117 | 100 % |

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## NUMBER OF CHILDREN

| No. of Children | Frequency | Percent |
|---|---|---|
| No Child | 5 | 4.3 % |
| 1 - 3 Children | 96 | 82.1 % |
| 4 - 6 Children | 16 | 13.7 % |
| Total | 117 | 100.0 % |

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## SMOKING HABITS OF TPO'S

| Smoking Habit | Frequency | Percentage |
|---|---|---|
| Smokes | 9 | 7.7 % |
| Do Not Smoke | 108 | 92.3 % |
| Total | 117 | 100 % |

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## Inferences

- Smoking as a confounding factor did not significantly affect the outcome of the study
- Any health effect was to a great extent attributed to ATMAP.
- The results compares well with the findings of Sharat *et al.*, (2011), who demonstrated that the respiratory effects of ATMP among nonsmoking TPO's of Patiala, India was majorly due to vehicular exhausts

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- He observed from his study that there was a significant decline in various parameters examined such as forced vital capacity (FVC), forced expiratory volume in one second (FEV ), and peak expiratory flow rate (PEFR) on the exposed nonsmoking TPO's when compared with the controls

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## PLACE OF RESIDENCE FOR TPO'S

| Place of Residence | Frequency | Percentage |
|---|---|---|
| Langata | 7 | 6.0 % |
| Pangani | 18 | 15.4 % |
| Kamkunji | 32 | 27.4 % |
| Umoja | 3 | 2.6 % |
| Kasarani | 10 | 8.5 % |
| Central Police Station | 25 | 21.4 % |
| Embakasi, Utawala, Quarry, Industrial Area, | 4 | 3.4 % |
| Baba Dogo | 1 | 0.9 % |
| Eastleigh | 5 | 4.3 % |
| Mathare | 1 | 0.9 % |
| Ngong | 2 | 1.7 % |
| Others | 9 | 7.7 % |
| Total | 117 | 100 % |

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## The results suggest that:

- Most TPO's 57 (48.8 %) besides being exposed to ATMAP during working hours still resided in areas that are suspected to be polluted with automobile emissions These results are comparable with the findings of a study carried out by Kinny *et al.*, (2000), in Ontario Canada which demonstrated that there was an increased risk of mortality from heart and lung diseases in people living within 100 meters of a roadway.

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## ENERGY USED FOR EITHER COOKING OR LIGHTING

| | Cooking | | Lighting | |
|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage |
| Paraffin | 33 | 28.2% | 3 | 2.6% |
| Firewood | 3 | 2.6% | 0 | 0.0% |
| Gas | 53 | 45.3% | 2 | 1.7% |
| Electricity | 17 | 14.5% | 112 | 95.7% |
| Charcoal | 11 | 9.4% | 0 | 0.0% |
| TOTALS | 117 | 100.0% | 117 | 100.0% |

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## The results reveal that:

- A majority of the traffic police staff 112 (95.7%) prefered electrity as the main form of enegy for lighting while 2.6% and 1.7% prefered to use paraffin and gas respectively. However, when it came to cooking, there is a shift from the use of electricity as the prefered form of energy. 53 (45.3%) of the TPO's prefered gas, followed by 33 (28.2%) who prefered paraffin while 17 (14.4%) prefered electricity for cooking. 11 (9.4%) and 3 (2.6%) of the TPO's prefered charcoal and firewood respectively for cooking.

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## There are three major findings from the results.

i. Electricity is easily accessible in the city suggesting wide spread connectivity.

ii. TPO's preffered to use electricity as the main form of energy for lighting while gas was preffered as the form of energy for cooking.

iii. The results suggest that indoor air pollution exposure may not play a significant role in affecting the health of the TPO's since a majority of the TPO's used form of energy that is clean burning.

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## PERIOD OF EXPOSURE: Period worked in Nairobi CBD as TPO

| Prd worked in Nbi CBD | f | Percentage % |
|---|---|---|
| Less than one year | 19 | 16.2% |
| Between 1 & 2 Years | 47 | 40.2% |
| Between 2 & 3 Years | 21 | 17.9% |
| Over 3 Years | 30 | 25.7% |
| Total | 117 | 100% |

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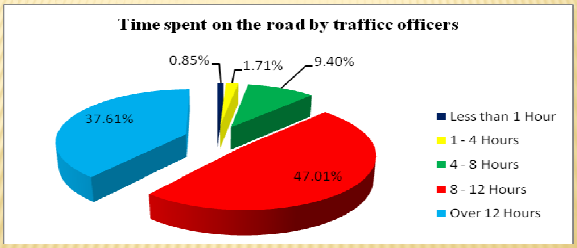
## Period spent on the road by TPO's while discharging duties




- 99 (84.62%) TPO's spent mandatory 8 hours or more and 18 (11.96%) spent 8 hours or less
- The average years worked in CBD by TPO's was 2.5 years.

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- Results suggest that although the average period worked in Nairobi CBD by the TPO's was 2.5 years, a significant percentage 30 (25.7%) of the officers had worked in the CBD for more than three years and a majority 99 (84.62%) of the TPO's were exposed for long periods on daily basis.
- Results compares with those previously reported elsewhere in other parts of the world (Peters *et al.*, 1999; Zemp *et al.*, 1999; Gauderman *et al.*, 2000; WHO, 2002; Finkelstein *et al.*, 2004; Bell, 2006 and Michael *et al.*, 2008).



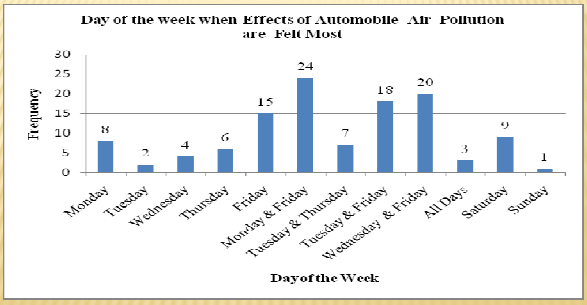


- TPO's mainly compained of sneezing, flue, irritation of the throat, nose, eyes and lungs.
- These results are comparable to the fndings of Proietti *et al.*, (2005), who demonstrated in his study in Catania, Italy that a truly exposed TPO's assigned to direct traffic suffered a greater prevalence of symptoms (Cough, wheeze and dyspnoea) and positive reaction to skin allergy tests compared with the truly non-exposed group i.e. TPO's working in administrative offices.



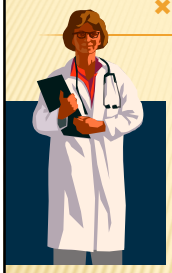


## Day of the week when effects of automobile pollution are most felt







- Friday recorded the highest percentage with 12.8 % (15) of the TPO's, followed by Saturday with 7.7% (9), Monday with 6.8% (8) while Thursady had 5.1% (6). The lowest percentage was reported on Sunday with 0.9% (1).





- On a combination of days, Monday and Friday recorded the highest percentage 20.5% (24), followed by Tuesday and Friday with 15.4% (18) while Tuesday and Thusday had 6% (7) .
- Effects were felt most as the days progressed from Monday through out the week.





- There was also some relationship and consistency observed between the day when the effects were most felt and the day when traffic density was reported to be high in the CBD. This is most likely due to the cumulative effects of the pollutants on their host as days progressed on and the concentration of the pollutants on these days.
- The results agrees with the findings of Bell, (2006)

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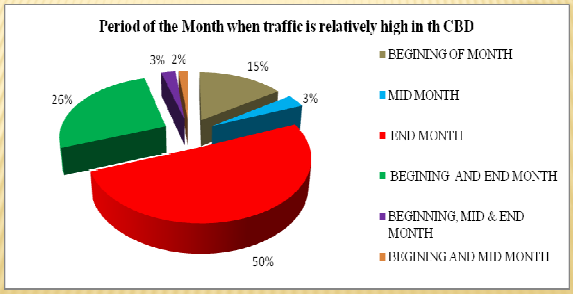
## Period of the month when traffic density is high in the CBD in Nairobi

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## Effects of automobile pollution on the health of the TPO's

| Score | Frequency | Percentage |
|---|---|---|
| 40 to 65 | 103 | 88.0% |
| 39 | 12 | 10.3% |
| < 39 | 2 | 1.7% |
| Total | 117 | 100.0% |

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- The TPO's complained mainly of sneezing, flue, irritation of the throat, nose, eyes and lungs.
- The results compares with the fndings of Proietti *et al.*, (2005), who demonstrated in Catania, Italy that exposed TPO's assigned to direct traffic suffered a greater prevalence of symptoms (Cough, wheeze and dyspnoea) and positive reaction to skin allergy tests compared with the truly non-exposed group

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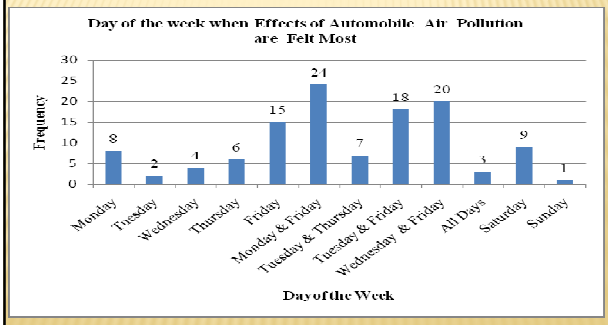
## Day of the week when effects of automobile pollution are most felt

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- Friday recorded the highest percentage with 12.8 % (15). Followed by Saturday with 7.7% (9), Monday with 6.8% (8) while Thursady had 5.1% (6). The lowest percentage was reported on Sunday with 0.9% (1).
- On a combination of days, Monday and Friday recorded the highest percentage with 20.5% (24) of the TPO's stating that they felt the effects most on these days

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## The results show that :

- The effects were felt most as the days progressed from Monday through out the week.
- There was some relationship observed between the day when the effects are most felt and the day when traffic density was reported to be high in the CBD due to
  - The cumulative effects of the pollutants on their host as days progressed on and
  - The concentration of the pollutants.

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## Day of the week when effects of automobile pollution are most felt

- These results agrees with the findings of Bell, (2006) who reported in his study that the health effects of the pollutants in an individual is directly dependent on the exposure period and toxicity of the pollutant

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## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

- Summary- The TPO's

i. Exposed to automobile $CO_2$, CO and $NO_x$ emissions levels above OEL and WHO values,
ii. Most of them were in the age bracket 26 to 45 years
iii. Spend more time on the road,
iv. Gases were negatively correlated with wind velocity,

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v. Smoking and indoor air pollution did not significantly affect the results of the study
vi. Traffic density was high during
   a) The morning and evening periods
   b) At the beginning and at the end of the month
   c) Personal cars the major causes of traffic congestion in the CBD,
vii. Effects of ATMAP were felt most towards the end of the week and the days when traffic density was relatively high,

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## CONCLUSIONS

i. Automobile emissions levels for $CO_2$, CO and $NO_x$ in Nairobi CBD were above the OEL and WHO values
ii. TPO's exposed were at high risk of being affected by the pollutants or are already affected
iii. Effects of ATMAP were most felt at the end of each week and during the period when traffic density was relatively high
iv. Personal vehicles were largely responsible for the traffic congestion in the CBD during the beginning and at the end of the month

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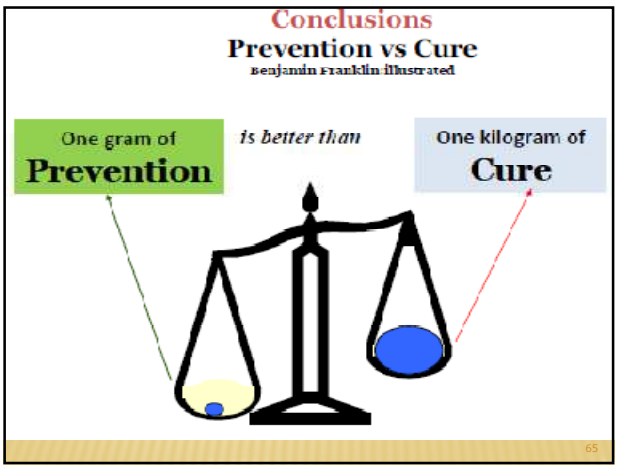


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## RECOMMENDATIONS

- Primary Preventive Measures

i. Establishment of air quality management capabilities,
ii. Establish and enforce air quality standards,
iii. Establish automobile air pollution policies that aim at reducing the exposure of the general population

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## RECOMMENDATIONS CONT..

- Secondary Preventive Measures
  i. Establishing and implementing a system of rotation of duties
  ii. Reducing the number of officers exposed at any given time
  iii. Providing the TPO's with suitable personal protective devices





# THANK YOU