Studying for Vehicular Emission on-road of Ulaanbaatar

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Abstract: In this paper we described the methodology to take control of air pollution due to toxic wastes from auto vehicles and experiment the state of the pollution from auto vehicles in Ulaanbaatar. In the paper we focused on the issues such as analyzing the pollution of toxic wastes from auto vehicles in Ulaanbaatar, processing the methodology to define the factors which affect ecological statistics adversely by auto vehicles, traffic organization during the use of the cars.

Key words: Auto vehicles, poisonous waste, burned gas and ecological statistics

1. INTRODUCTION

Auto vehicles pollute not only atmosphere, water and soil but also have adverse effect on vibration of auto vehicles, electric magnetic ray and noise. Exhaust gas of internal combustion engines (ICE) of auto vehicles is a compound which consists of over 270 species and contains a number of carcinogen gases. Since poisonous gas spreads in the magnitude of human breath in environment, it is the most dangerous polluter for the atmosphere.

Exhaust gas from the engine of auto vehicles is not the only emission. Loss of acid from the accumulator battery, antifreeze from the cooling system due to the loss of sealing, loss of wheel erosion, noise and vibration are still polluting the environment. Hence, creating the effective methodology to take control of auto vehicles, diagnosing the ecological state of auto vehicles and
checking the level of air pollution from the roads in center of the city have become important issues.

2. THE FACTORS INFLUENCING ON ECOLOGY DURING THE USE OF AUTO VEHICLES

2.1 How the environment factors influence ecological statistics of auto vehicles

The pollution to the atmosphere depends on natural factors as speed and direction of the wind, humidity and temperature, geographical location and specialty of grass. The natural phenomenon wind, pressure and humidity have a vital effect upon use of auto vehicles, saving condition and its technical and economical and ecological statistics. To the main factors of atmosphere, including environmental air temperature have direct effect on physics and chemical characteristics of materials of use and because of that, body of auto vehicles, engine start and processing procedure change.

When the environment temperature is 20°C, there is a little carbon, carbohydrates and nitrogen oxide in the exhaust of ICE. The more temperature increases the faster the process for the fuel evaporation and the concentration is increased.

2.2 How the arrangement for traffic influences ecological statistics

The concentration of poisonous substance in the exhaust of ICE depends not only on factors like nature, atmosphere and saving condition but also on condition for the arrangement for traffic.

Although there are research works on amounts of poisonous waste to be changed depending on the speed from auto vehicles, this is the basement of well organizing the traffic defining the ecological damage in a true way.

3. THE METHOD TO DEFINE THE FACTORS INFLUENCING ON ECOLOGICAL STATISTICS

Defining the level of influence on ecological statistics from auto vehicles is one of the problems to be solved.

The independent object’s influences on environment is a direction of the traffic in traffic network. Here we determine the statistics that defines the level of the direction of the traffic and the influencing to influence on ecological statistics of auto vehicles.

Basic equation for the direction of the traffic

\[ N_a = K \cdot V \]  (1)

\(N_a\) - traffic intensity, sec\(^{-1}\); \(K\) – direction density, m\(^{-1}\); \(V\) – speed of traffic, m/sec.

Here is a scheme to define ecological statistics from the factors of auto vehicles in Figure 1.
It is possible to define many factors of ecological statistics of auto vehicles according to the first picture. Of many problems in urban areas, air pollution and noise are the major problems to be solved. In the article, there is a method to define the factors of auto vehicles state in the characteristics of atmosphere in city. To estimate in traffic procedure, we considered on-running waste of auto vehicles as \( w \) (mg/m), wind speed as \( M \) (m/sec), concentration of poisonous substance in atmosphere for ecological statistics as \( Y \) (mg/m\(^3\)).

We established that the factors of ecological statistics depend on air concentration. If the wind speed increases, it the scattering level of poisonous substance in atmosphere increases, thus the concentration decreases. In the contrary case, it has a inverse relationship. Hence, let’s build the second scheme to define the concentration of poisonous substance using the first scheme.
Here we considered the following parameters in order to mold the above scheme with the help of unit theory.

1. We used $N_a$ traffic intensity for the factors influencing on ecological statistics of auto vehicles. If so, the following ratio will be possible according to the unit theory.

$$\frac{Y}{N_a} = \text{or} \left[ \frac{mg}{m} \right] \cdot \left[ \frac{1}{sec} \right] \cdot \left[ \frac{sec}{m} \right] = \left[ \frac{mg}{m^3} \right]$$

It expresses that it is essential that another parameter be used for this method as shown in the above example.

2. We used $V$ speed of traffic for the factors influencing on ecological statistics of auto vehicles. Speed of traffic of auto-vehicles defines the term runs through the length of a road being assumed. The slower the cars move on the length of the road, the worse for the ecological statistics. Therefore the speed of traffic has inverse relationship with the ecological statistics. According to the theory the following ratio will be possible.

$$\frac{Y}{V} = \text{or} \left[ \frac{mg}{m} \right] \cdot \left[ \frac{sec}{m} \right] \cdot \left[ \frac{sec}{m^2} \right] = \left[ \frac{mg \cdot sec^2}{m^3} \right]$$

Like the above, it doesn’t meet the requirements of theory.

3. Let’s use $K$ traffic density for the factors influencing on ecological statistics of auto vehicles. On this occasion like the above, it doesn’t meet the requirements of theory as well.
4. Let’s assume the vehicular flow energy into the parameter of auto-vehicles. On this occasion let’s assume $E_k \ (m/\text{sec}^2)$ kinetic energy or $I \ (m/\text{sec}^2)$ internal energy of vehicular flow. The more kinetic energy of vehicular flow there, the less energy loss there, if so ecological statistics will be like that as well. On the other hand,

$$
\frac{E - k}{[M]} = [m] \quad \text{or} \quad \frac{E - k}{[m]} = [m] 
$$

(5)

$$
\frac{mg}{[m]} \cdot \frac{m}{[m \cdot \text{sec}^2]} \cdot \frac{\text{sec}}{[m]} = \frac{mg}{[m^3]} \quad \text{or} \quad \frac{mg}{[m]} \cdot \frac{\text{sec}^2}{[m]} \cdot \frac{\text{sec}}{[m]} = \frac{mg \cdot \text{sec}^3}{[m^3]} \neq \frac{mg}{[m^3]} 
$$

(6)

It also doesn’t meet the requirements of theory for the above factors after checking its result. Therefore we came to a conclusion that the methodology we use doesn’t express the ecological statistics influencing on the environment from auto-vehicles. We need to estimate the experiment dependence among factors of auto-vehicles and factors of ecological statistics or to define the quotient adjusts the unit in order to help out the above problem. For this, let’s define what unit the affection unit will have using the unit theory.

$$
\frac{w}{[M]} \cdot [m] = [m] \cdot \frac{sec}{[m]} \cdot [m] = \frac{mg}{[m^3]} 
$$

(7)

From here it will be like this,

$$
\frac{mg \cdot \text{sec}}{[m^2]} \cdot [m] \neq \frac{mg}{[m^3]} \quad \implies \quad \frac{mg}{[m^3]} \cdot \frac{m^2}{mg \cdot \text{sec}} = \frac{1}{[m \cdot \text{sec}]} 
$$

(8)

We can come to a conclusion that the unit of the factors affect to the ecological statistics from auto-vehicles must be “$(m \cdot \text{sec})^{-1}$” according to the expression.

We are making the analysis in high traffic intensity condition of auto-vehicles and we can determine the volume of toxic substance be lost in the air in the part $L$ of a road after assuming the non-stop freight movement in the part of a road with the length $L$ during the term of $T$.

$$
Q = \sum_{i=1}^{n} w_i \cdot l_i 
$$

(9)

Here, $n$- the number of cars cover the part with the length $L$ within the term of $T$; $w_i$ - toxic waste from auto-vehicles during the traffic, $mg/m$; $l_i$ – auto vehicles distance to cover the road part, $m$. 
Dispersion level which defines the concentration of toxic substance in the atmosphere depends on the air volume. So that the concentration of toxic substance comes out from cars will be defined as the following:

\[ Y = \frac{O}{Q} \]  

(10)

Here is the air volume in which the toxic substance disperses, \( m^3 \); We assume the air variation into two basic states:
- Air volume variation depending on weather condition
- Air volume variation depending on traffic in the part of a road being researched.

The main parameter of dynamic unit of air volume depending on weather condition is a wind direction and speed. If we assume the linear variation, the wind direction has a little significance and the main factor which evaluates the affection of the weather is the wind speed. If so, dynamic volume of the air will be expressed as the following way:

\[ O = L \cdot \Delta O \cdot R_z \]  

(11)

Here, \( \Delta O \) - linear variation of the air volume in the term of \( T \) during the observation, \( m \); \( R_z \) - average space which cars take up within the term of \( L \), \( m \); \( R_z \) – the main factor which affects on parameter \( \Delta O \) is \( M \) the wind speed and is defined within the whole term \( T \) and \( \Delta O \) has a direct relationship to these parameters.

\[ \Delta O = T \cdot M \]  

(12)

Parameter \( R_z \) must be defined with the parameter which is similar to density of freight movement and has a similar data.

Parameter the above can be expressed as the following: If the car I cover the distance \( l_i \) with the length of \( L \) of a road, the meaning of the loaded state of given part of a road will be defined as:

\[ Z = \frac{\sum_{i=1}^{n} t_i}{T} \]  

(13)

The average space which the cars take up has inverse relationship with \( Z \)- parameter.

\[ R_z = \frac{L}{Z} = \frac{L \cdot T}{\sum_{i=1}^{n} t_i} \]  

(14)

Thus, if (12) and (14) can be substituted, dynamic volume of the air is expressed as the following form:
\[ O = L \cdot \Delta O \cdot R_z = L \cdot T \cdot M \cdot \frac{L \cdot T}{\sum_{i=1}^{n} t_i} \]  \hspace{1cm} (15)

If the concentration of toxic substance on the atmosphere is defined during the whole term \( T \) of observation using the expression (9) and (15), it will be

\[ Y = \frac{Q}{O} = \frac{\sum_{i=1}^{n} w_i \cdot l_i \cdot \sum_{i=1}^{n} t_i}{L \cdot T \cdot M \cdot L \cdot T} \]  \hspace{1cm} (16)

And the following conclusion can be done by observing the expression to define the concentration of toxic substance from auto vehicles.

By defining the state of parameter \( R_z \) and \( Z \), \( R_z \) has inverse relationship with the density of freight movement.

\[ K = \frac{1}{R_z} = \frac{Z}{L} = \frac{\sum_{i=1}^{n} l_i}{L \cdot T} \]  \hspace{1cm} (17)

Waste and the concentration of toxic substance in the air depend on the waste from each car during the term \( T \). If we compare the total space of the cars which cover the part with the length \( L \) of a road to the length of the part, the traffic intensity will be expressed as the following form:

\[ n = \frac{\sum_{i=1}^{n} l_i}{L} \]  \hspace{1cm} (18)

\[ N_a = \frac{n}{T} = \frac{\sum_{i=1}^{n} l_i}{L \cdot T} \]  \hspace{1cm} (19)

If the average data of the ecological factors of auto-vehicles is defined without estimating the own waste from each car,

\[ Y = \frac{\sum_{i=1}^{n} w \cdot l_i \cdot \sum_{i=1}^{n} t_i}{L \cdot T \cdot M \cdot L \cdot T} = \frac{\bar{w} \cdot \sum_{i=1}^{n} l_i \cdot \sum_{i=1}^{n} t_i}{L \cdot T \cdot M \cdot L \cdot T} \]  \hspace{1cm} (20)

If we present the expression (20) with the final version using the expressions (17) and (19), there will be

\[ Y = \frac{\bar{w} \cdot N_a \cdot K}{M} \]  \hspace{1cm} (21)
The expression shows that the ecological statistics depends on not only the traffic intensity but also the traffic intensity and density of the freight movement. Let’s check how the formula extraction of \([x]\) parameter matches.

We considered that this method fits in with reality because the unit theory meets the requirement. As a result of researching, the expression (21) is a mathematical model which will defines the ecological statistics.

\[
x = N_a \cdot K \text{ or } 1 = \left[ \frac{1}{m \cdot \text{sec}} \right]
\]

(22)

Observing from the expression above, the ecological statistics depends not only on intensity, but also traffic intensity and the density of the direction of the traffic.

4. THE RESULT OF THE RESEARCH ON THE TOXIC WASTE ON THE ATMOSPHERE FROM AUTO-VEHICLES IN ULAANBAATAR

There made the mathematic processing with the help of the program SPSS of the mathematic processing after measuring the content (CO, NO₂, SO₂) of toxic waste in fourteen roads and crossroads with high traffic intensity 60 times between 8:00am and 8:00pm in January, February, March, April, October and December between 2006 and 2009.

For sulphurous gas (SO₂) in the air, it was analyzed with the tools of (MNS 0017-2-512:98) Minipump SIBATA MP 300 (Japan) with the method tetrahlormercurator and for nitric dioxide (NO₂), it was analyzed with the tools of (MNS 0017-2-5-11:98) SIBATA MP 30 (Japan) with the method of Griss-Ilov or naftilamin photometer.

Data table is shown in Figure 3. Location – the number of 14 roads and crossroads – front side of Sukhbaatar square; wind direction – the wind direction – numbering from 1 to 8 from the north-west; wind speed – the wind speed; the average value of measuring nitric dioxide NO₂; the average value of measuring sulphurous gas SO₂; the average value of measuring carbon protoxide CO; the average intensity of the traffic; temp – weather condition.
In the content of toxic substance of internal combustion engines there completed determination quotient of traffic intensity and air temperature, regress equation and disperse analysis. The result of the analysis is shown in table 1.

### Table 1 The result of the experiment

<table>
<thead>
<tr>
<th>Analysis of influencing for environment temperature</th>
<th>Analysis of influencing for traffic intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression Analysis: CO versus temperature</td>
<td>Regression Analysis: CO versus traffic intensity</td>
</tr>
<tr>
<td>The regression equation is</td>
<td>The regression equation is</td>
</tr>
<tr>
<td>CO = 0.089 - 0.0692 temperature</td>
<td>CO = - 1.52 + 0.0462 traffic intensity</td>
</tr>
<tr>
<td>Predictor Coef SE Coef T P</td>
<td>Predictor Coef SE Coef T P</td>
</tr>
<tr>
<td>Constant 0.0893 0.1425 0.63 0.531 tempar -0.069208 0.009108 -7.60 0.000</td>
<td>Constant -1.5220 0.1984 -7.67 0.000 erchim 0.046165 3.490 13.23 0.000</td>
</tr>
<tr>
<td>S = 1.66956 R-Sq = 18.8% R-Sq(adj) = 18.4%</td>
<td>S = 1.42081 R-Sq = 41.2% R-Sq(adj) = 40.9%</td>
</tr>
<tr>
<td>Analysis of Variance</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>Source DF SS MS F P Regression</td>
<td>Source DF SS MS F P Regression</td>
</tr>
<tr>
<td>1 160.95 160.95 57.74 0.000</td>
<td>1 353.13 353.13 174.93 0.000</td>
</tr>
<tr>
<td>Residual Error 250 696.86 2.79</td>
<td>Residual Error 250 504.67 2.02</td>
</tr>
<tr>
<td>Total 251 857.81</td>
<td>Total 251 857.81</td>
</tr>
</tbody>
</table>
Regression Analysis: NO$_2$ versus temperature
The regression equation is
\[ \text{NO}_2 = 65.5 - 0.206 \times \text{temperature} \]
Predictor Coef SE Coef T P
Constant 65.479 3.723 17.59 0.000
tempar -0.2057 0.2379 -0.86 0.388
S = 43.6091  R-Sq = 0.3%  R-Sq(adj) = 0.0%

Analysis of Variance
Source DF SS MS F P
Regression 1 1421 1421 0.75 0.388
Residual Error 250 475438 1902
Total 251 476859

Regression Analysis: NO$_2$ versus traffic intensity
The regression equation is
\[ \text{NO}_2 = 61.3 + 0.0126 \times \text{traffic intensity} \]
Predictor Coef SE Coef T P
Constant 61.270 6.083 10.07 0.000
Traffic intensity 0.01258 0.07 0.18 0.241
S = 43.5540 R-Sq = 0.5% R-Sq(adj) = 0.2%

Analysis of Variance
Source DF SS MS F P
Regression 1 2621 2621 1.38 0.241
Residual Error 250 474238 1907
Total 251 476859

Based on the experiment result we posted a hypothesis regarding the influence of environment temperature and traffic intensity. According to our hypothesis we carried out some empirical studies in some parts of Ulaanbaatar’s on-road traffic. The result of the empirical analysis is indicated in table 2.

Table 2 The result of correlation analysis

<table>
<thead>
<tr>
<th>Location</th>
<th>NO$_2$</th>
<th>SO$_2$</th>
<th>CO</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>west across road</td>
<td>NO$_2$</td>
<td>Pearson</td>
<td>.473(*)</td>
<td>.964(*) - .075</td>
</tr>
<tr>
<td></td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N = 18</td>
<td>.047 .036 .769</td>
</tr>
<tr>
<td></td>
<td>SO$_2$</td>
<td>Pearson</td>
<td>.473(*)</td>
<td>.963(*) - .169</td>
</tr>
<tr>
<td></td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N = 18</td>
<td>.047 .037 .503</td>
</tr>
<tr>
<td></td>
<td>CO</td>
<td>Pearson</td>
<td>.964(*)</td>
<td>.963(<em>) - .982(</em>)</td>
</tr>
<tr>
<td></td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N = 18</td>
<td>.036 .037 .018</td>
</tr>
<tr>
<td></td>
<td>temperature</td>
<td>Pearson</td>
<td>-.075</td>
<td>-.169 - .982(*)</td>
</tr>
<tr>
<td></td>
<td>Correlation</td>
<td>Sig. (2-tailed)</td>
<td>N = 4</td>
<td>.769 .503 .018</td>
</tr>
</tbody>
</table>

- Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).
Like Figure 3 the correlation flat was built for NO₂, SO₂ and we came to a conclusion that the content in CO revealed by observing the environment temperature and for NO₂ the affection of the environment temperature was very loose in 3 crossroads and for SO₂ is affection was also loose in 4 crossroads while in 11 crossroads there are different affection. Thus we chose the form (23) and described the correlation flat depends on the unit (24).

Correlation of toxic gas (CO, NO₂, and SO₂) from ICE and air temperature indicated in following equation.

\[ Y = a \log(t + c) + b \]  

\[ U = \log(t + c) \]  

Figure 4 Correlation of environment temperature and CO mass

Figure 5 Mass of toxic (NO₂, SO₂, CO) and U (Inverse)
After solution above regression equation we find that empirical equation:

For CO

\[ Y = 32.6 - 16.3 \lg(t + 60) \]  

(25)

For NO\textsubscript{2}

\[ Y = 288 - 97 \lg(t + 200) \]  

(26)

For SO\textsubscript{2}

\[ Y = 30 + 2.5 \lg(t + 200) \]  

(27)

Empirical graphic of above equations (25, 26, and 27) indicated in Figure 6.

![Graphs showing empirical equations for CO, NO\textsubscript{2}, and SO\textsubscript{2}](image)

Figure 6 Mass of toxic (CO, NO\textsubscript{2}, and SO\textsubscript{2}) in exhaust gas of ICE versus temperature

Air pollution of Mongolian cities may be a matter of geographical location, for example basin of rivers, lowlands and temperature differences between lowlands and highlands in winter.
5. CONCLUSION

- In recent years, many types of equipments have been developed to define the volume of poisonous substance secreted from auto vehicles. However it is essential that we have common and mobile equipment to measure the content of exhaust gas from internal combustion engines.
- Also we developed the mathematic sample to define the average volume of gas content emitted from auto vehicles.
- We found out that volume of poisonous substance from auto vehicles depends not only on condition of climate and their uses but also their speed. The speed of auto vehicles basically depends on the quality of the road and frequency of traffic lights.
- We suggest that a method to review the mathematic sample of ecological character and measure the poisonous volume from auto vehicles to atmosphere in the result of our research.

REFERENCES