

Quantifying Urban Karachi's Air Quality Effect on Human Health and Policy Recommendations

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Abstract- Today's environmental issues are systematic in nature and cannot be tackled in isolation from man-made activities and impacts. The change in land use and land cover resulting from urbanization has aggravated air quality in urban centers of the country. One of the main sources of air pollution is the use of automobiles in human populated regions resulting in an excess of carbon, sulfur and nitrogen compounds. The emission of greenhouse gases in the form of carbon dioxide from 1990 to 2005 showed an increase of 97.4%. The main source of this increment were vehicular and industrial emissions due to which Pakistan is facing glacier melt in northern areas, earthquakes, flooding and lack of fresh water availability. The authors analyze the effects of vehicular emission on human health; this study is focused on the commercial and industrial areas of Karachi where the flow of heavy traffic and heavy vehicular exhaust emissions are common. The sampled areas are Port Qasim, University Road, Korangi and Mosmiyat. The purpose of this study is to evaluate perceptions of health factors due to air borne pollution in 4 different localities in Karachi. The results showed predominance of headache which is due to an excessive quantity of carbon monoxide and air borne dust in the survey areas as slight exposure of Carbon monoxide affiliated with headache, the second highest complain from respondents is the Eye Irritation, the exposure of NO₂ has acute health effects which include eye irritation, cough and asthma. Based on the above study, recommendations are made to reduce GHG and other pollutants.

Keywords: Health Effects, Vehicular Emission, Karachi Air content.

I. INTRODUCTION

In urban areas of Pakistan vehicles are major source of producing air pollution [1] and cause 70 percent of pollution in environment [2]. According to the Karachi Metropolitan Corporation (KMC) the total number of registered vehicles increased from 2,614,580 to 3,127,463 in the year 2011-2013[3],[4], this rapid increase contribute towards vehicular emissions like CO (Carbon Monoxide), NO₂ (Nitrogen Oxide), SO₂ (Sulfur dioxide) and Green House Gases (GHG) like CO₂. The effect of these pollutants is degradation in human health, environment and agriculture.

Carbon monoxide has the biggest share among all the emissions due to unburnt natural gas constituents, whereas CO₂ burning of fossil fuel is the secondary constitute of these vehicular

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emissions. Vehicle emissions can cause adverse impact on human health results in coma, headache, breathing difficulty, eye Irritation, cough and asthma.

A recent survey by the World Health Organization (WHO) in 2012 reported that air pollution causes 72% of deaths due to heart disease and strokes, while 14% deaths occur from respiratory infections; the remaining 14 % occur due to lung cancer. A similar assessment done in 2013 by the WHO's International Agency for Research on Cancer (IARC) warned about the increasing cancer incidents within the country due to the continuous increase of air pollutants [5].

A. Climate Change in Pakistan due to Carbon Dioxide (CO₂)

Emission of Carbon dioxide from 1990 to 2005 increased by 97.4% the main source of this increase are vehicular and industrial emissions, the weight age of vehicles contributing towards air pollution is estimated between 60-70% [6]. Hence, we are facing climate change in Pakistan such as glacier melt in northern areas, earthquakes, Floods, lack of fresh water availability etc.

B. Climate Related Natural Hazards

Pakistan is now facing a climate related natural hazards of Heat-Waves which attacked on June 2015 due to this the number of mortality occurs especially in Karachi, during 17th to 24th June the Heat-Wave scrolls most of the country and the highest temperature were recorded as 49°C in Larkana and Sibi, 45°C in Karachi [7].

C. Problem Statement

The environmental impact from vehicular exhaust emission is often neglected in Pakistan due to the lack of awareness in our society, which is the major factor contributing to vehicle emission that includes NO₂ (Nitrogen Oxide), Carbon dioxide (CO₂), Carbon Monoxide (CO) and other pollutants. This is demonstrated in the commonly used Euro standard where Pakistan's information and input is minimal. Human health, vegetation and environment of Pakistan are adversely affected due to this negligence standards. As can be seen from Figure 1, Pakistan does not exhibit any conclusive information about Euro standards due to its non-implementation.

D. Study Objectives

The main study objectives of this research are as follows:

- 1) Qualitative analysis of vehicular exhaust emission impact on human health specifically headaches and relationship to locations with active vehicle exhaust emissions.
- 2) Policy recommendation to reduce pollutants in order to aid planners and decision makers.

Country	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14				
European Union	E1	Euro 2				Euro 3				Euro 4			Euro 5			Euro 6								
Bangladesh ^a												Euro 2												
Bangladesh ^b	Euro 1																							
Hong Kong, China	Euro 1	Euro 2				Euro 3				Euro 4			Euro 5											
India ^c							Euro 1			Euro 2				Euro 3										
India ^d					E1	Euro 2				Euro 3			Euro 4											
Indonesia	Euro 2																							
Malaysia	Euro 1				Euro 2										Euro 3			Euro 4						
Nepal	Euro 1																							
Pakistan	No conclusive information available																							
Philippines									Euro 1			Euro 2				Euro 3					Euro 4			
PRC ^a							Euro 1			Euro 2			Euro 3			Euro 4								
PRC ^e							Euro 1			Euro 2			Euro 3			Euro 4 Beijing only								
Singapore ^a	Euro 1				Euro 2																			
Singapore ^b	Euro 1				Euro 2				Euro 3												Euro 4			
Sri Lanka									Euro 1				Euro 2								Euro 3			
South Korea													Euro 4			Euro 5								
Taipei											US Tier 1					US Tier 2 Bin 7 ^g								
Thailand	Euro 1				Euro 2				Euro 3				Euro 4											
Viet Nam													Euro 2											

Figure 1. Emission Standards for Light-Duty Vehicles

II. LITERATURE REVIEW

Vehicles are the main source of producing ground level ozone which is an air pollutant and have an adverse impact on human health and environment [8]. In the United States vehicles account for 51% of Carbon monoxide (CO), 34% of Nitrogen Oxides (NOx) and 10% of Particulate Matter (PM) every year [9].

A. Impacts of Carbon Monoxide on Environment and Health

Carbon Monoxide (CO) may be a standout amongst a few pollutants that could associate in the vicinity of daylight to produce ground-level ozone, "Smog" especially with respect to high temp midyear times [10].

Carbon dioxide is colorless, odorless and highly toxic gas, under the Clean Air Act (CAA) the Carbon monoxide is decelerated the hazardous for our environment and human health. Carbon monoxide (CO) mainly produced by incomplete combustion of fuel from vehicles and this chemical is in the list of special health hazards substances.

Following are the short-term health effects that may occur instantly or shortly due to the exposure of carbon monoxide.

- Inhaling of Carbon monoxide (CO) may cause headache, dizziness and fatigue [11]
- Higher exposure can cause sleepiness, memory changes, mental confusion and loss of vision [12]

B. Impacts of Sulfur Dioxide on Environment

When the emission of sulfur dioxide occurs, it causes acid rain. When acid rains fall down it damages forests, vegetation and it also affects our Eco System. The sulfur dioxide also effects visibility; it reduce visibility due to their high light scattering ability as well as resulting in a haze in the environment [13].

C. Impacts of Sulfur Dioxide on Human Health

Sulfur dioxide (SO₂) is a colorless gas having the sharp and irritating smell and produced in the atmosphere due to the burning of coal, fuel, etc. when the SO₂ dissolved in the air it produce major amounts of pollutants which affects human health. When a person experiences 8-12 ppm level exposure of SO₂ for couple of minutes cause throat irritation, where 20 ppm cause cough and eye irritation immediately [14]. According to World Health Organization the sulfur dioxide is more harmful for those who are suffering from lung, cardiac and asthma problems [15].

D. Impacts of Nitrogen Oxides on Environment

Nitrogen oxides are the composition of nitrogen and oxygen, the main sources of producing nitrogen oxides are vehicles, burning of coal, oil and other fuel burning process. When the reaction of Nitrogen oxides (NO_x) and sunlight occur, it forms Smog, acid rain [16] and leads to Ozone when it reacts to volatile organic compounds (VOC) [17].

E. Impacts of Nitrogen Oxides on Human Health

Nitrogen oxides are also harmful for human health; the safe exposure limit for Nitrogen dioxide (NO₂) is 5 ppm with the time limitation of up to 15 minutes which should not exceeds more than 4 times in a day and the gap between the exposures should be 1 hour [18]. The direct exposure of Nitrogen Dioxide (NO₂) damage the cells of lung tissues and the acute health effects are eye irritation, Throat infection, lung infection and it also triggers asthma in asthmatics [14].

III. METHODOLOGY

A. Questionnaire Survey

The survey was done in four different areas of Karachi. The purpose of this study to determine the effects of pollutants on the health of individual. The interviewee sample size was 50, which divided into four different areas Port Qasim, University Road, Korangi and Mosmiyat were distributed among selected individuals who work or live in the study areas was 12, 13, 12 and 13 respectively. Here the population size of 5,000,000+ is appropriate for margin of error of 11% and the amount of uncertainty that can be tolerated is 90%. This gives us a sample size of 49.

B. Focused Group

Two focus group discussions conducted in Korangi and University Road were used to gather information about the health impact due to vehicular emissions. The focused group consisted of 8 participants which live, work and study in the affected areas.

IV. RESULTS

The 50 participants are randomly selected for the sampling from four locations; the locations are based on current automotive settlement. The effect of headache is predominant in the survey questions. However only for IoBM there is no differentiation between headache and sleeplessness.

A. Qualitative Survey Result

- 1) *Port Qasim*: In Port Qasim the sample size was 12, where 50% respondents affected by Headache. It is observed that in this area buses and trucks emit poisonous gases as they are unmaintained and old, 33.3% respondent suffering from sleeplessness which linked to heavy eye as the Port Qasim is a commercial hub and the respondents may stay for a greater period of time for the whole day. 25% respondents affected from Cough and allergy while 16.6% respondents suffered from eye irritation and asthma which caused due to heavy emissions from trucks. As can be seen in Figure 2 vehicle emission does have an impact on human health. We see that Headache has been reported to be the most significant cause of health deterioration based on the survey followed by sleeplessness and allergic reaction. Coughs and eye irritation are then closely followed lastly by Asthma.

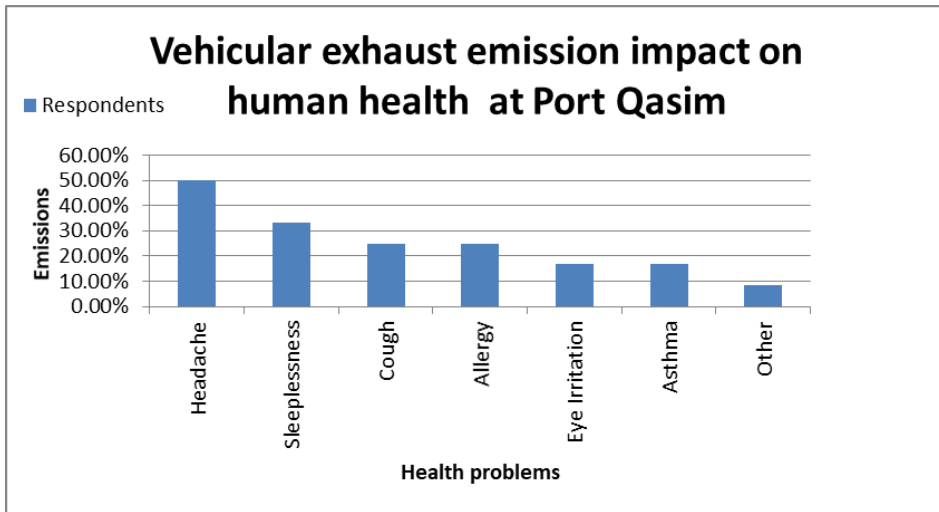


Figure 2. Vehicular Exhaust Emission Impact on Human Health at Port Qasim

- 2) *University Road:* The respondents were suffered from a headache and Eye Irritation at University Road area is higher than other areas with 69.23% and 61.53% as in Figure 3. This is due to the vehicles emit large amounts of exhaust gases during the daytime while 30.77% respondents affected by cough because the bus stops are near with banks, offices and universities due to that heavy traffic occurs, 15.38 % suffered from allergy and 7.69% respondent was effected by eye irritation and asthma.

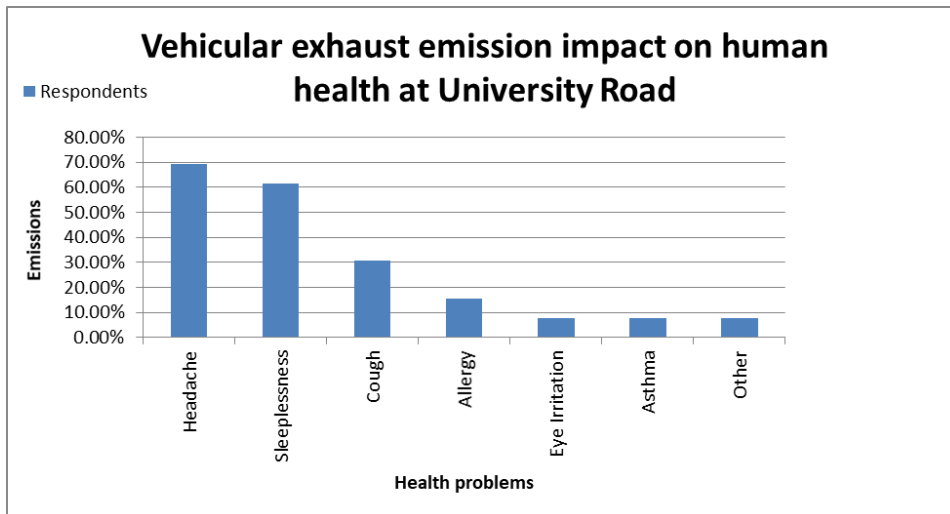


Figure 3. Vehicular Exhaust Emission Impact on Human Health at University Road

- 3) *Korangi*: At IoBM 38.46% respondents were suffered from Cough, 30.77% respondents affected by sleeplessness, as this is partially residential, industrial and commercial area and emission from neighbor bus stops and car parks during the day may result in sleeplessness while 23% respondents faced headache and allergy due to a mixture of gases from different sources. This is shown in Figure 4.

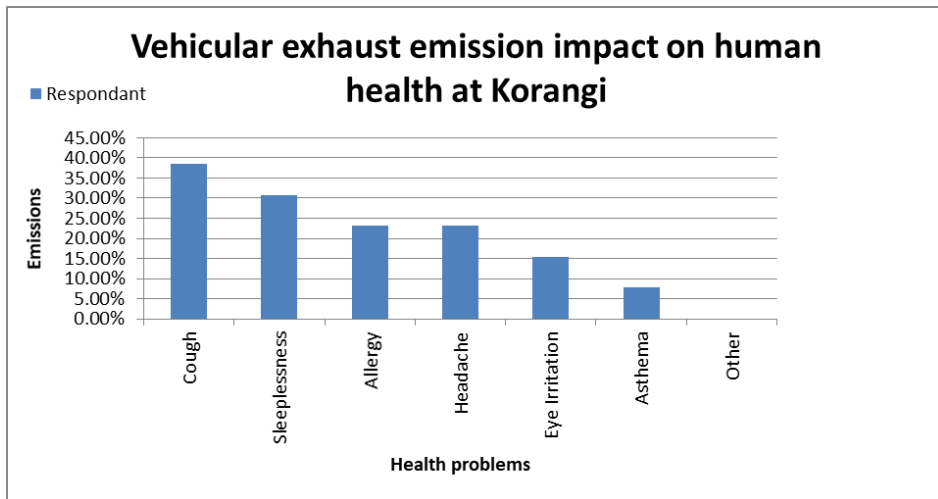


Figure 4. Vehicular Exhaust Emission Impact on Human Health at Korangi

- 4) *Mosmiyat*: At Mosmiyat as shown in Figure 5, 50% respondents have complained of Headache and 42% Eye Irritation due to the commercial area and having the greater quantity of buses, cars and old vehicles, 25% respondents have Cough, Allergy and Asthma due to lack of space in small buses, cars and other vehicles.

The results shown in Figures 2 to 5 point that out of four areas the respondents of three areas having the highest complains of headache. According to Public Health, England slight exposure of Carbon Monoxide (CO) is affiliated with Headache [19]. The exposure of NO₂ has acute health effects which include Eye Irritation, Cough and asthma [18]. Moreover, according to the Environmental Protection Agency (EPA) the short term exposure of NO₂ having the range from 30 minutes to 24 hours affects the person's health and may cause asthma [20].

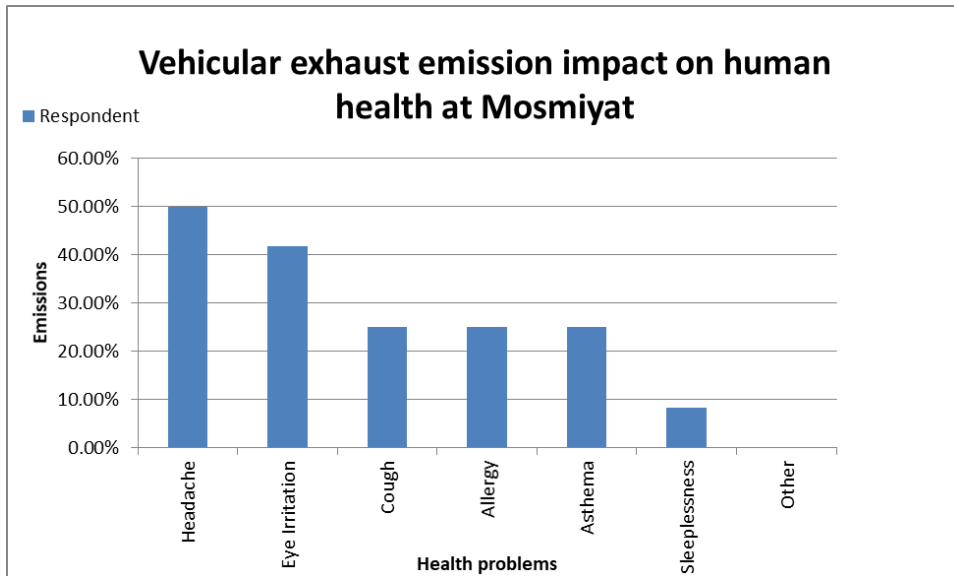


Figure 5. Vehicular Exhaust Emission Impact on Human Health at Mosmiyat

5) *Focus Group*: The length focus group discussion was approximately 15 minutes of each group, the specific questions regarding which type of vehicles participant use, duration of exposure per day, what are the vehicle emissions impacts on their health and what they suggest to reduce vehicle emissions was interviewed. The following questions were asked in the focus group discussion:

Question 1: what type of vehicle used for the traveling?

The usage of private transport for traveling is high rather than public transport due to bad reputation; no facilities provide people face inconvenience in rush hours, the condition of buses in Pakistan are poor with lack of availability due to that people prefer to use private transport. As seen in Table I, within group 1 eight out of three participants used car at higher rate for traveling even for short distance on the other hand group two participants used motorcycle whereas the usage rate of public transport is lower.

TABLE I
DURATION OF EXPOSURE TO VEHICLE EXHAUST EMISSION PER DAY

	Group 1 University Road	Group2 Korangi
Motorcycle	02	04
Car	03	02
Rickshaw	02	01
Bus	01	01

Question 2: Duration of Exposure to vehicle exhaust emission per day?

Air pollution is serious issue regarding the health risk as vehicles are increasing day by day the poor quality of air also increasing which affects the human health as the people face higher duration of exposure to vehicle exhaust emission per day, the risk of increasing health impacts are also high. In the group discussion we found that people mostly exposure exhaust emission four to five hours per day and summarized in Table II.

TABLE II
VEHICLE TYPE USED FOR TRAVELLING

	Group 1 University Road	Group 2 Korangi
1 – 3 hours	03	02
4 – 10 hours	05	06
10-14 hours	-	-
14 and above	-	-

Question 3: What do you think what the impacts of vehicular emission on human health?

The higher concentration of air pollutants are harmful for us specially in the rush traffic hours, when the people exposed to high level of air pollutants may cause eye, nose, throat irritation, cough, breathing difficulties, asthma and may cause heart problem. The long term exposure of air pollutants may cause cancer and damage to the immune, neurological, reproductive, and respiratory systems.

Question 4: Suggest the ways for reducing exhaust emission

Representative responses:

- Traffic laws related with pollution and exhaust should be imposed
- Improve public transport facility

- Proper Roads and traffic monitoring system help to reduce emission
- Reduce Private transport and Increase usage of bicycle
- The Government should influence automobile industry to invest R&D vehicle pollution
- Prepare schedule for the car maintenance and use the recommended motor oil.

B. Statistical Test to Categorize Vehicle Emission Impact on Health

Here we apply a statistical test to verify our results and conclude the major form of health concern which is easy to identify namely headache. In this case, we use the observed values shown in Table III.

TABLE III
OBSERVED DATA FOR CONTINGENCY DATA OF HEALTH IMPACT RESEARCH

Location	Headache reported	Other health issues reported	Total respondents
Port Qasim	6	6	12
University Road	9	3	12
Korangi	8	4	12
Mosmiyat	3	10	13
	26	23	49

The reported sample size is 12 for each location, where the majority of the medical issues are related to headaches. Since headaches can be easily identified and linked to automobile exhaust emission it has been considered here. The test results were analyzed for the following hypothesis using Chi-square test method.

H₀ - Headaches are not dependent on locations with active automobile exhaust

H₁ - Headaches are dependent on locations with active automobile exhaust

The determination is categorical and the above is the case for observed data. The expected values are given in Table IV.

TABLE IV
EXPECTED VALUE OF CONTINGENCY TABLE FOR HEALTH IMPACT RESEARCH

Location	Headache reported	Other health issues reported	Total respondents
Port Qasim	6.367346939	5.632653061	12
University Road	6.367346939	5.632653061	12
Korangi	6.367346939	5.632653061	12
Mosmiyat	6.897959184	6.102040816	13
	26	23	49

Establishing a level of significance to be 0.05, the degree of freedom is $r-1 * c-1$ which is 3. The X^2 value obtained is 7.95. For 2 degrees of freedom and alpha being 0.05 using the Chi Square table the cut off is 7.82. Since the $X^2 > X$ cutoff we obtain can now reject the null hypothesis. Hence, health impact characterized by headache is dependent on locations with active vehicle exhaust emission.

The above validates our finding on the topic and can be used to prove our hypothesis that health is impacted by locations where industrial and automobile exhaust emissions take place.

IV. POLICY RECOMMENDATIONS

The effect of exhaust on human health helps to focus on reducing exhaust pollutants and Green House Gases emissions as the transportation sector is responsible for the highest growth emission rate and responsible for a quarter of carbon dioxide emission in Pakistan [21]. For this purpose, we have to develop and implement policies that will help reduce vehicle emissions from cars, trucks, motorcycles, buses and rickshaws in Pakistan.

A. Increase Green Public Transport

One favorable way is to introduce environmentally friendly large transportation systems as in Figure 6.



Figure 6. Green Bus as Public Transport

The increase in public transport plays an effective role in reducing carbon emission and other air borne pollutants. The government needs to consider increasing provision of public transport like green buses and identify routes and availability of green buses in every area of the city. It is

important to concentrate on time management, fare reduction, provision of food and additional services which attract the people towards public transport instead of using private transportation.

If an individual which drive 32 km round-trip use public transport to travel he or she will contribute to reduce annual CO₂ emissions by 4,800 pounds per year [22].

B. Vehicle Inspection and Maintenance

It is crucial to create public awareness on the importance of vehicle maintenance to reduce GHG and other harmful pollutants emissions with the help of the media. The policy should make for vehicle inspection and maintenance through which we are able to control the vehicle emissions. Government should organize a campaign to setup vehicle maintenance service centers to inspect vehicles two times in a year free of cost.

C. Ban Old Vehicles and Recycle

The vehicles which are older than 15 years need to be phased out. The reason is that old engines wear out quickly and deposit incomplete combustion by products. There is a need in Pakistan for the government to launch a scheme for old vehicles scrap, where the vehicle owner gets money in return of old vehicle and certificate which help the owner in buying new vehicle with discount.

D. Plant Trees

Due to climate change, temperature of Pakistan is raising almost a fraction of degree every year. The one way to control climate change is to plant as much trees as possible. This can be the main source of reducing carbon dioxide (CO₂). Young trees are able to absorb carbon dioxide (CO₂) more quickly.

E. ECO-Driving

Due to toxic emissions, carbon dioxide (CO₂) is produced by man-made activity in the environment can be controlled by adopting ECO-Driving. It is estimated by experts that on average, for every liter of petrol used in a motor vehicle, 2.2 kilograms of Carbon Dioxide are released from the exhaust [23]. In Pakistan people are unaware of the benefits of ECO-Driving. This needs to be incorporated as it is not only the best way to reduce exhaust emissions to save the environment but also saves on our fuel consumption with an average of 15 % of fuel costs [24].

F. Implement Euro Vehicle Standards

In Pakistan some of the vehicles are EURO II standards specifications. Pakistan had initially agreed to adopt EURO II in 2012. However, this was postponed till 2014 but unfortunately the adoption of EURO vehicles in Pakistan is negligible on the other hand our neighbors China and India have already practiced these standards. India is recently using EURO III and EURO IV standards for their vehicles, whereas China is following EURO IV [25]. The implementations of these emission standards are necessary to reduce the pollutants effects on environment and human health and in Pakistan we should adopt at least EURO VI standards to avoid further problems regarding vehicle pollutants.

IV. CONCLUSION

Based on the study the finding indicates that the effects from vehicle exhaust pollution cause diseases like Asthma, Cough and also eye irritations and have adverse effect on human health. The way to decrease transport emission can be achieved by the reduction in fossil fuel combustion and by increasing the transport energy use efficiency. To reduce the impact of vehicle emission levels on human health the various methods can be applied which include:

- Improved fuel economy helps to improve the efficiency of vehicles.
- Implementation of EURO standards vehicles.
- Introduce big buses and train in transport system to facilitate public this helps to avoid the more and frequently usage of private vehicles.
- The alternative fuel like bio fuels is another way to reduce the vehicle emissions.
- Traffic Management.
- Walking and cycling must be encouraged as the alternative mode of transport.
- Ban Old Vehicles
- Encourage Car Pooling system

The government should focus on the fuel economy improvement, ban old vehicles and non-EURO vehicles, traffic management and introduce campaign to aware the people about the impact of vehicle emissions and to promote ECO-Driving in Karachi. Further specific recommendations with respect to the areas under research are as follows:

- 1) More localized sampling and testing at different premises and locations within the city. A campaign at IoBM was started recently where average carbon footprint measured in premises was verified to be 0.1 metric tons CO₂ per year in Karachi.

- 2) Further proposals for pollutant level and the impact of actual versus expected CO₂ emissions to be incorporated before suggested recommendations to be incorporated by SEPA and other regional environmental agencies and Municipal Town Office in Karachi.

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