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Investigation and Evaluation of Ambient Air Quality in Various Parts of Karachi Metropolitan City, Pakistan

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Abstract: Various parameters of ambient air have been collected from dissimilar areas of Karachi with the purpose of study to check the quality of the ambient air and its effects on the human health. For the analysis of the ambient air, mobile van was used in Sohrab Goth area and mobile station was used in Defence and North Nazimabad areas. Total of ten different gases and five environmental parameters were analyzed. The concentrations of the pollutants of the ambient air usually found high in winter while moderate in summer season. Most of the parameters of the pollutants were found above the permissible limits, while the National Environmental Quality Standard (NEQS) of various gases such as Methane, Non Methane Hydrocarbon, Total Hydro Carbon and Methane Carbon were not established in any studies. The concentration of Carbon Monoxide in all three areas was found with in a permissible limit of National Environmental Quality Standard (NEQS). It was also observed that the concentrations of each pollutant were increasing terrifyingly with passage of time which may be responsible to damage the healthy environment of Karachi. It may also enhance global warming and depletion of ozone layer.

Key words: Air pollution · Ambient air · Ozone depletion · Global warming · Pollutants

INTRODUCTION

The atmosphere of the earth is a thin layered collection of gases, water vapor and particles having most living creatures' introduction live in the atmosphere [1]. Major man-made sources of ambient air pollution include industries, automobiles and power generation which released continuously in to atmosphere while indoor environments emits tobacco smoke, combustion of solid fuels for cooking and heating [2]. Some ambient air pollution is also contributed by natural activities such as forest fires, volcanic eruptions, decay of vegetation, winds and sand or dust storms [3]. The magnitude of the problem of air pollution in Karachi has increased alarmingly due to population explosion, industrialization, urbanization, automobiles and other human proclivities for greater comfort. The poverty, poor hygiene and pollution are responsible for the various blood related deficiencies and diseases in the population of Karachi [4]. The diesel exhaust contains several gaseous compounds including carbon monoxide, nitrogen oxides, sulphur dioxide and organic vapors [5]. There is a category of people which are affected by air pollution in different ways such as poor people, undernourished people, very young, very old and people with preexisting respiratory disease and other ill health are more at risk. Poor also tend to be more malnourished, more likely to suffer from ill health and disease and have less access to health care [2]. Long term effects of air pollution might slightly change the survival curve (ageing) of a population [6]. Diesel emissions may also be a problem for asthemics, people with asthma who live near roadways with high amounts of diesel truck traffic have more asthma and use more asthma medication [7]. Nitrogen dioxide, nitrogen oxides, carbon monoxide were the pollutants most often linked with coronary heart disease [8]. Tobacco smoke can contain very high concentrations of carbon monoxide 1,000 ppm to 50,000 ppm [5]. Health impact of air pollution depends on the pollutants type, its concentration in the airs and length of exposure [2]. Diesel particles consist mainly of elemental carbon and other carbon-containing compound which include aromatic hydrocarbons and other compounds that

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have been associated with tumor formation and cancer [5]. The purpose of present investigation is to describe present status of air pollution in different areas of Karachi. It is hopped on the basis of this data better planning for pollution control would be possible.

MATERIALS AND METHODS

During ambient air pollutants sampling, it is also necessary to collect information on qualitative and quantitative data on the local sources of air pollution, topography, population distribution, land use pattern, climatology, etc, depending upon the objectives of the survey or measurement campaign [9]. The air pollution monitors have to operate in a wide range between the natural background concentrations and the maximum concentrations occurring in an urban industrial atmosphere [10]. Three different districts has selected to study and analyzed the ambient air quality of the Karachi. These areas has classified on the basis of amount of traffic lifestyle, infrastructure, income and literacy of the people. The Horiba (AP-370 series), air pollution analyzers are used to monitored the ambient air pollution. The monitor allows to continuously measure the concentrations of oxide of nitrogen, nitrogen oxide and nitrogen dioxide by APNA-370, sulphur dioxide by APSA-370, total hydrocarbon, methane and non methane hydrocarbon by APHA-370, carbon monoxide by APCA-370 and ozone by APOA-370 in ambient air. APOA-370, APSA-370, APMA-370, APHA-370 APNA-370 is a standalone system which is operate by merely connecting a calibration gas diluter while measuring ozone and hydrocarbon a zero gas purifier and fuel gas H2 are supplied.

The concentrations of NO2 are calculated from those of NO and NOx. The APNA-370 monitor uses a combination of the dual cross-flow modulation semi decomposition Chemiluminescence method based on the reaction of NO and O3 which produce NO2. NOx is measured by diverting a separate sample flow through a thermal convertor prior to the addition of ozone (Review of the California Ambient Air Quality Standard for Nitrogen Dioxide 2007). Chemiluminescence results from a chemical reaction in which light is emitted from a species or compound that is in an excited state. The concentration of NO2 is calculated by subtracting the measured NO concentration from the measured NOx concentration (Review of the California Ambient Air Quality Standard for Nitrogen Dioxide 2007). The concentration of NO2 was obtained by the difference between the NOx concentration measured when the gas is directed through a converter and NO concentration measured when the gas is not run through the convertor (Horiba Instruments Model APNA-370 NO2 Monitor *Automated Reference Method*: RFNA-0506-157 "Horiba Instruments Incorporated Model APNA-370 Ambient NOx Monitor," standard specification, operated with a full scale fixed measurement range of 0 - 0.50 ppm with the automatic range switching off, at any ambient temperature in the range of 20°C to 30°C and wit h a 0.3 micrometer sample particulate filter installed. Federal Register: Vol. 71, page 25587, 2006). Accuracy and precision of the NO2 measurement are reflected in the field audit data (ARB 2004; ARB 2006). The H2 gas is used as supplementary gas. The APHA-370 continuously monitors atmospheric hydrocarbon concentrations using a cross flow modulated selective combustion type method combined with a hydrogen ion detection method which utilizes the ionization that occurs as the result of the high temperature energy from combustion at the tip of the burner jet when organic carbon compounds are introduced in to the hydrogen flame is located between two electrodes. When an electrical voltage is applied across these electrodes a minute ion current proportional to the hydrocarbon concentration is produced. This current is monitored by a low voltage leakage amplifier, giving voltage readout for THC.

To measure methane the sample gas passed through the selective catalytic combustion unit (the NMHC cutter) which oxidizes NMHC without oxidizing CH4. The APMA-370 is a device for continuously monitoring CO concentrations using non-dispersion cross modulation infrared analysis method. The cross flow modulation type, infrared-absorption technology eliminates the need for adjusting optical alignment. The APMA-370 uses an AS type (antishock) interference-compensating detector and a purified reference gas. The reference gas is generated by purging the sample through an oxidation process, where an oxidizing catalyst burns the CO to CO2.

These features eliminated interference from other elements, resulting in highly accurate measurement. The APOA-370 continuously monitors atmospheric ozone concentrations using a cross flow modulated ultraviolet absorption method. The APOA-370 uses the cross flow modulation type, ultra-violet absorption method in conjunction with the comparative calculation method. The ultra-violet absorption method works on the principle that ozone absorbs ultraviolet rays in the area of 254 nm. All gas connections are either PTFE or glass. As the analog output of concentrations, select either the

combination of monetary value and rolling average or that of monetary value and average (optional). The default setting is the combination of monetary value and rolling average. Addition of an RS-232C port (optional) will allow to carryout data communication. The system shall be upgraded with time to time and connected with a computer, monitor, recorder, calibration gas generator. The standalone system is a monitor unit which is connected with a power source and received a sample gas and high concentration calibration gas. The green signal shows that the machine operation is normal while red in alarms conditions.

For precise and accurate measurement of the ambient air, the filter of the panel change for every 2 weeks. The pressure of the calibrations gas inlet make stable within ±500Pa, while pressure of the sample inlet maintained at ±980Pa. In order to prevent condensation from occurring exercise caution to ensure that the sample piping is not exposed to cool air. The ambient temperature is maintained between 5-40°C. Large LCD touch screens displayed (117 x88 mm) the result of the ambient air. The measured gas of exhaust outlet with a connector for a Teflon tube of 6mm O.D./4 mml.D., release the measured gas to a safe location where the back pressure stays stable within a range of ±980 Pa. The measured gas is released from the exhaust outlet at a rate of 1.1 L/min.

RESULTS AND DISCUSSION

15 parameters of ambient air have been collected from the areas of Karachi in which only 2 parameters were found within a NEQS limit. There are 5 parameters of environmental factors and 10 parameters of gaseous factors. Figure 1, 2 and 3 are mean monthly concentration of 15 parameters of three years of Sohrab Goth, North Nazimabad and Defence areas, Karachi respectively.

Sohrab Goth: It is a gateway to Karachi from where heavy vehicles, trollers and loader used to enter or exit from Karachi to different areas of Pakistan. It is considered a lower class population from where all over hygienic situation is poor and unsatisfactory. Figure 1 shows the mean average concentration of CO and O3 are found below the NEQS in each 3 years. The mean average concentration of NO 32.1µg/m^3 and 33.81µg/m$^{3^3}$ are found below the NEQS in the month of February and November, while the mean average concentration of NO2 32.68µg/m^3 and 37.28µg/m^3 are recorded in the month of January and February. The lowest mean average limit of NOx 45.77 ppb and 40.11ppb are found in the month of January and November which are also below the NEQS. The mean highest concentration of NO, NO2, NOx and SO2 are 90.41µg/m^3, 87.18µg/m^3, 113.03 ppb and 171.18µg/m^3 recorded in April, March, May and September respectively which are above the NEQS. The mean average reading 19.82µg/m^3 and 27.51µg/m^3 of SO2 are found below the NEQS in January and February. Since the permissible limit of CH4 and its derivative such as NMHC and THC are not notified but the mean average concentration of methane and its derivatives are found in alarming condition.

The minimum mean value 502.31 ppb of NMHC are recorded in the month of September. The highest mean concentration 5824.25 µg/m^3, 3870.37 ppb, 10244.64 ppb of CH4, NMHC and THC are found in the month of April, July and March respectively. The methane carbon 77.97µg/m^3 and 35.31µg/m^{3}are recorded highest in the month of May and lowest in December. In December and April, highest and lowest wind speeds are recorded which are 4.55 m/s and 2.16 m/s. The highest mean average value of 41.2°C, 83.03 % of temperature and Relative Humidity are measured in April and December while lowest mean average 11.85°C and 51.43% are found in June. The permissible limit of methane, non-methane hydrocarbon, total hydrocarbon, methane carbon, wind speed, wind direction, temperature, relative humidity and radiation are not existed hence it is difficult to assess the quality of the ambient air.

North Nazimabad: It is one of the new areas of Karachi which is engaged in mostly residential and commercial activities. It is thickly populated area with middle to upper middle class population. The hygienic condition is better than other areas. Due to commercial activities, most of the areas comprise shopping plazas and malls which acquired diesel and gas based generators. Figure 2 shows the mean average level of NO, CO, SO2 and O3 were recorded below the permissible limits of NEQS in entire three years. The mean average limit 61.74µg/m^3, 52.95 ppb and 84.44µg/m^{3}of NO2, NOx and MC are found above the permissible National Environmental Quality Standards (NEQS) in the month of April and June while lowest levels 20.85µg/m^3,17.31 ppb and 37.61µg/m^3 of these parameters are found in the month of November. The NEQS of methane and its derivatives such as NMHC, THC and MC are not notified but over all parameters of ambient air of this locality is slightly better than other areas. The highest mean level 37.61 µg/m^3, 2.46 m/s, 285.29 degree and 32.26°C of methane carbon, wind speed, wind direction and temperature are observed in the month of November.

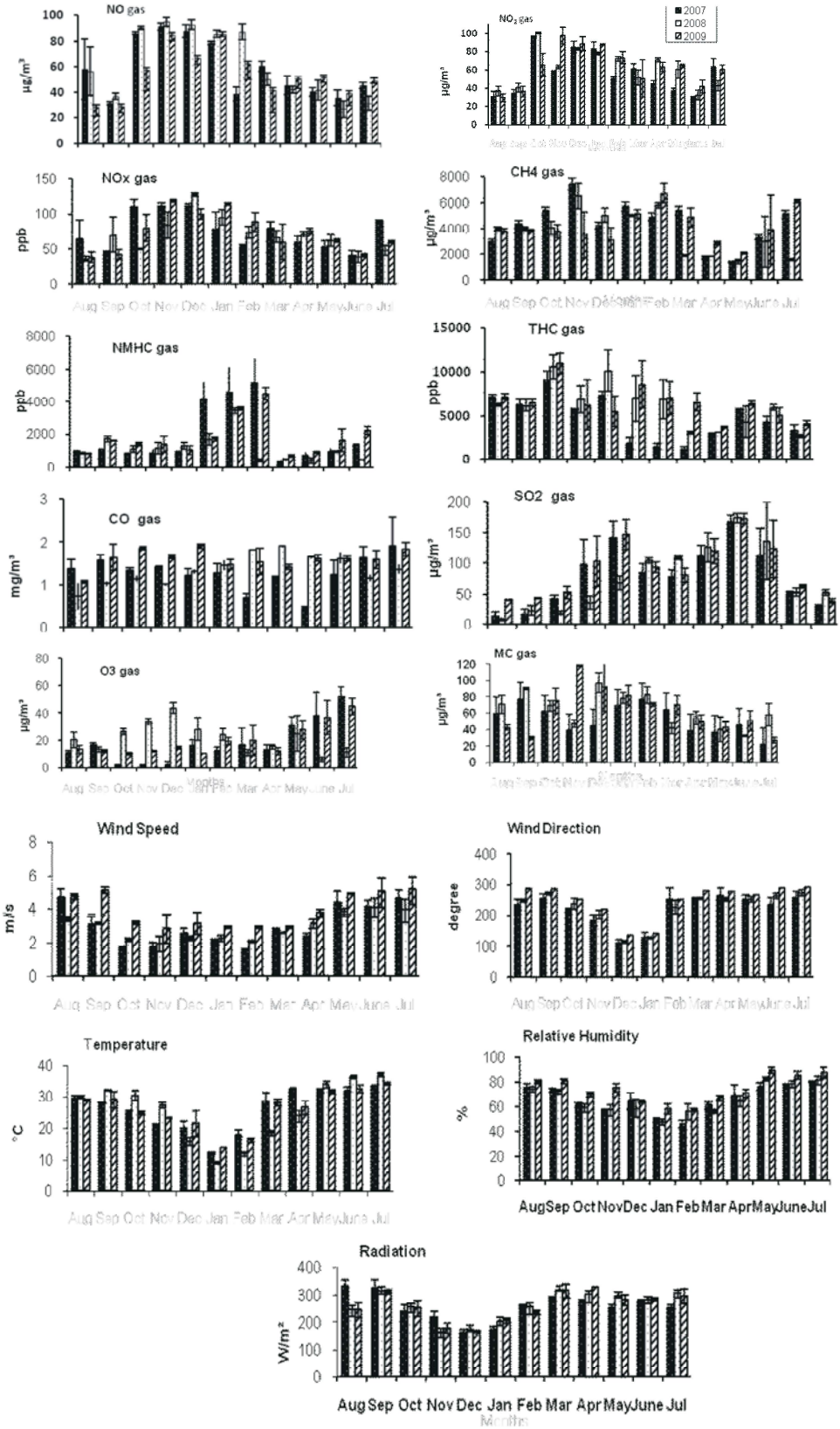

Fig. 1: Mean monthly variation of various parameters during three years of ambient air of Sohrab Goth area, Karachi

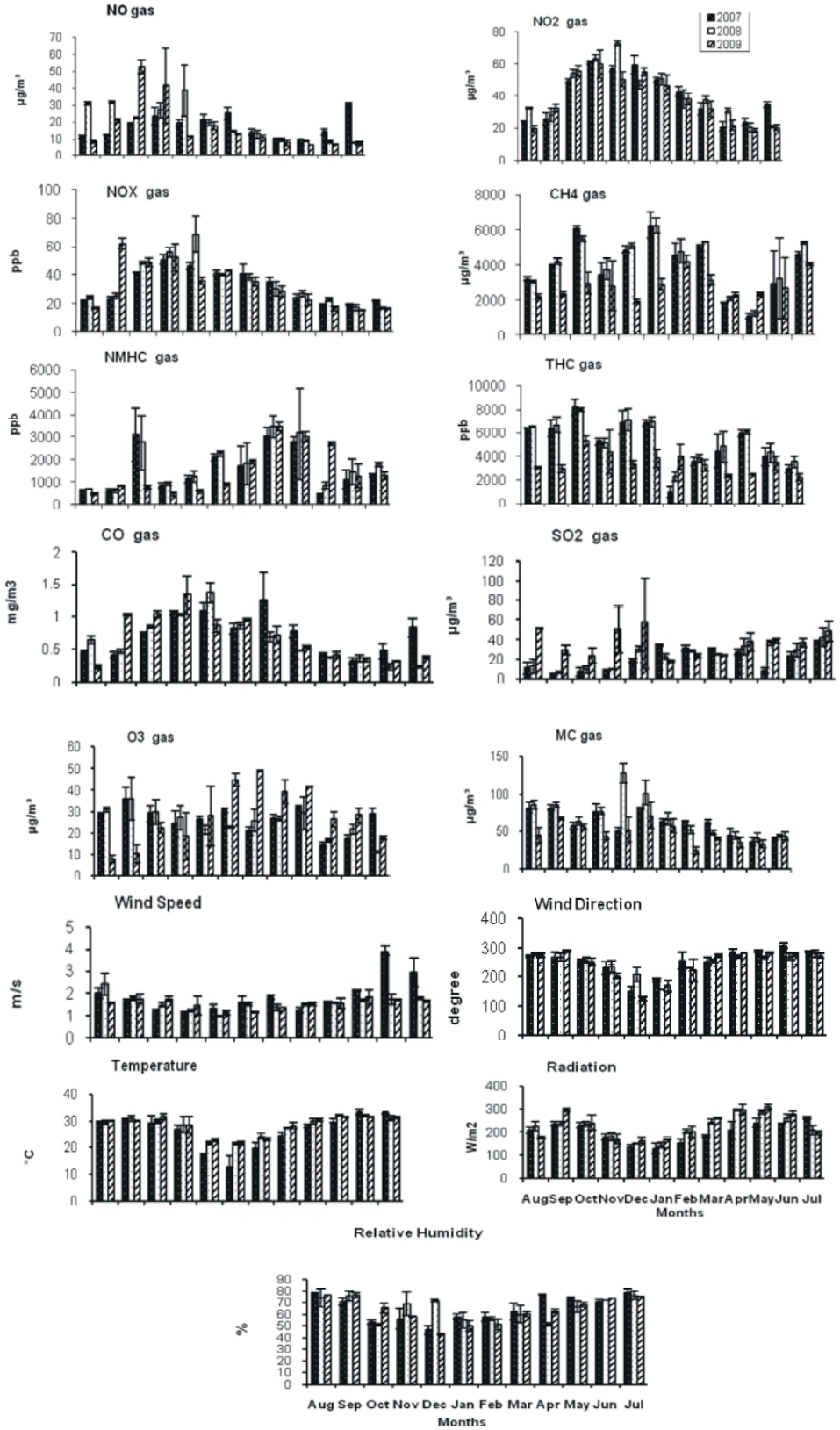

Fig. 2: Monthly variation of various parameters during three years of ambient air of North Nazimabad area, Karachi

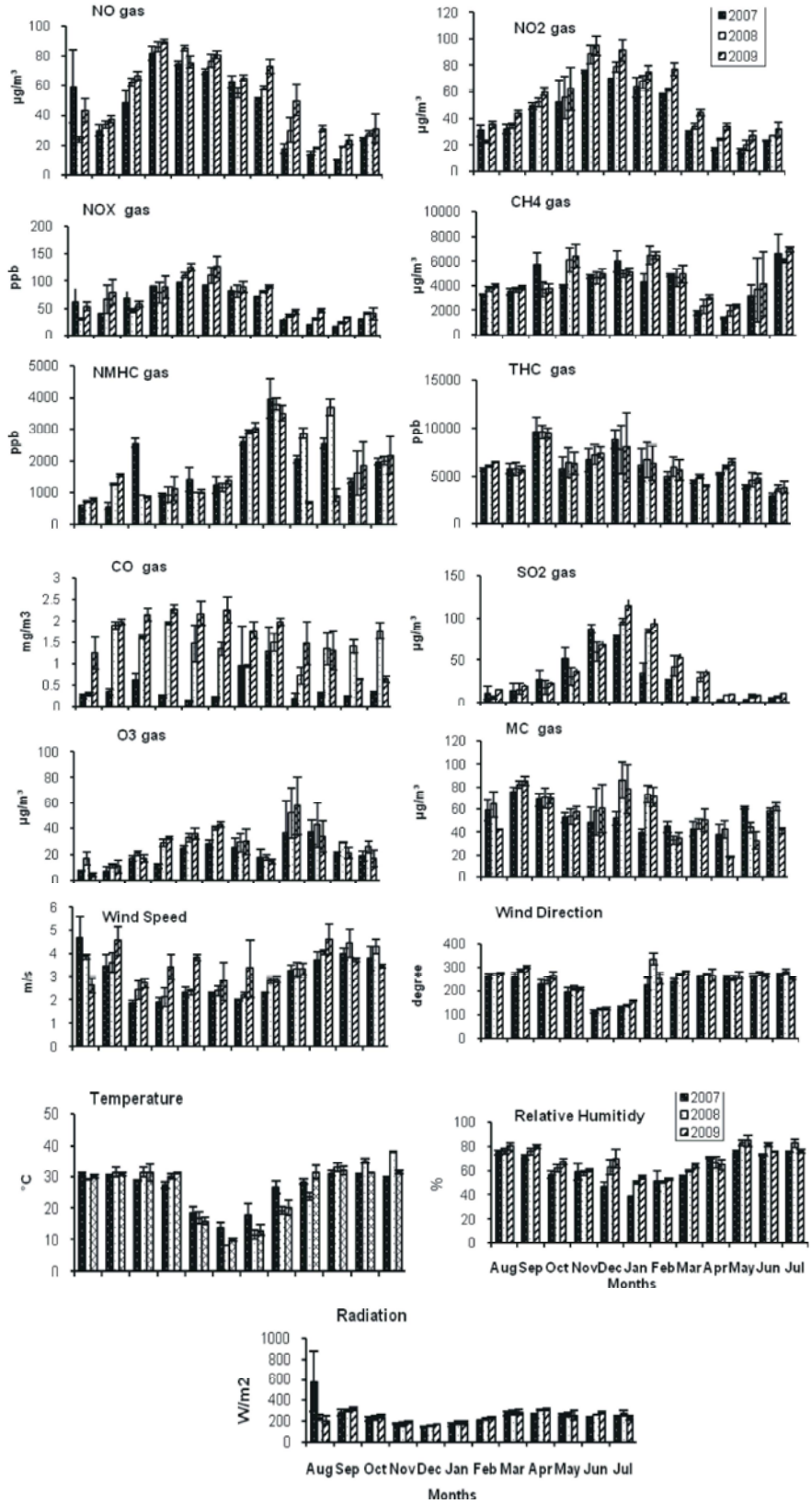

Fig. 3: Monthly variation of various parameters during three years of ambient air of Defence area, Karachi

Defence: It is open, posh and moderate populated but polluted area of the Karachi comprises upper class population and possesses high lifestyle people. Major portion of the area is residential while remaining occupied by commercial activities. In addition, this locality is adjacent to the seaside which helps to move the pollutant breeze along with towards seaside. Nearly all the residents owned more than two vehicles which enhance the potential of the pollution. Figure 3 shows the highest mean average level of NO2 and NOx 86.08µg/m^3 and 111.54 µg/m^3 are measured in the month of May.

The parameters of CO and O_3 analyzed in Fig. 1, 2 and 3 of all three years are found below the NEQS while the highest mean average level of SO_2 95.75 µg/m^3 which is above the NEQS recorded only in June. The highest mean average value 6527.59 µg/m^3, 3743.18 ppb, 9565.31 ppb, 81.17 µg/m^3 of CH4, NMHC, THC and MC are found in the months of December, August, March and February. The highest mean average of wind speed and Temperature are recorded in the month of October and December. The highest mean average value among all three areas of NO, NO_2, NOx and SO_2 91.41 µg/m^3, 87.18 µg/m^3, 113.03ppb, 171.18 µg/m^3 are found in Sohrab Goth which is above the NEQS while 6527.59 µg/m^3 of CH4, 3870.37 ppb of NMHC and 10244.64 ppb of THC are also found higher among in the areas of Defence, Sohrab Goth.

Karachi city which comprises more than 20 millions of population have no choice to live in acute as well as chronic condition. NO, NO2, NOx, CO, SO2, methane and its derivative are generated from different sources such as industries, vehicles, generators, fossil fuel mining, livestock and open waste dump sites or burning which are responsible to gradually exceeding the permissible level of NEQS. The Sohrab Goth area, which is nearest to New Karachi industrial area and a pathway to enter or exit of Karachi from different city of Pakistan from where most of the parameters of the ambient air are found above the NEQS. The present study also shows that the hygienic situation of the area is unsatisfactory while the lifestyle of the people, income level, poverty level and education level of the area is very low which also enhance the pollution level. Urban atmosphere pollution has a well known impact on acute and chronic respiratory disease, where as it effect on cardio respiratory disease has been analyzed more recently [11]. Most of the carbon monoxide in the atmosphere is due to human activities such as automobile exhausts which accounts for 60% of CO in the atmosphere and city has about more than 1 million automobiles. Forest fires and agricultural burning (i.e. burning of forest debris, crop residues, bushes weeds and vegetation, which contributes to about 17% of the CO in the atmosphere. However higher amount of CO is contributed in the city by open garbage burning in hundreds of places and dumping sites. Industrial operations such as electric and blast furnaces in iron and steel industry, petroleum refinery, paper industry, gas manufacture (which constitutes about 9.6% of CO in the atmosphere) [5]. In Person, inhaled carbon monoxide reacts very rapidly with hemoglobin in the blood, preventing uptake and transport of oxygen. NO and NO2 are more significant from air pollution point of view and they are usually represented together as NOx [12].

The oxidation of NO to NO2 is also favoured at high temp (-1100°C) but the amount of NO2 is also favoured usually not more than 0.5% of the total NOx present. NO2 is also formed by photolytic reactions in the atmosphere [5]. The relationship between urban pollution and ischaemic heart disease seems to affect all age groups [13]. Nearly 67% of the global SO2 pollution is due to volcanic activity and other natural sources, over which we have no control, the remaining 33% of SO2 emission is because of human activities such as combustion of fuels, coal-fire, power stations, transportation, refineries, chemical plants and manufacture of sulphuric acid [5]. SO2 is a very water-soluble gas and most of the SO2 is inhaled is absorbed in the upper respiratory tract and does not reach the lung's airways [5].

The concentration of some of the parameters of ambient air has been gradually increasing in each three years in each area. NO in Defence continuously increased from September to June while in North Nazimabad it is decreasing from February to July. In Sohrab Goth, the concentration of NO gradually increased only in the month of April and gradually decreased in the month of May in three years while the concentration of NO2 remain constant in the month of December in all three years. Most of the pollutant in various months of 2008 is found less as compared to 2009 and 2010. Figure 3 describe the pollution level of NO2, NOx and SO2 of Defence area which are considered well established and developed are increasing gradually with passage of time. Even in Defence area not a single parameters were decreased gradually with passage of time. In North Nazimabad, the concentration level of NO2 in the month of February, March, June, July and SO2 in the month of March, April and May are gradually decreased in three years. Urban atmospheric pollution has a well known impact on acute and chronic respiratory disease where as it effect on cardio respiratory disease has been analyzed more recently [8]. Most of the man-made SOx pollution is concentrated in urban and industrial areas.

Table 1: Permissible limit of the various parameters of ambient air of Pakistan

Name of the Pollutants	Symbol	Permissible Limits	Method Of Measurement
Nitric Oxide(Annual Average)	NO	40 µg/m^3	Gas Phase
24 Hours		40 µg/m^3	Chemiluminescence
Nitrogen Dioxide (Annual Average)	NO2	40 µg/m^3	Gas Phase
24 Hours		80 µg/m^3	Chemiluminescence
Oxide Of Nitrogen	NOx	50 ppm	Chemiluminescence
Methane	CH4	Not Established	N/A
Non-Methane Hydro-Carbon	NMHC	Not Established	N/A
Total Hydro-Carbon	THC	Not Established	N/A
Carbon Mono-oxide (8 Hours)	CO	5 mg /m^3	Non Dispersive
1 Hours		10 mg/m^3	Infra-Red (NDIR) Method
Sulphur Dioxide (Annual Average)	SO_2	80 µg/m^3	Ultraviolet
24 Hours		120 µg/m^3	Fluorescence method
Ozone (1 Hour)	O_3	180 µg/m^3	Non dispersive UV method
Methane Carbon	MC	Not Established	N/A
Wind Speed	-	N/A	N/A
Wind Direction	-	N/A	N/A
Temperature	-	N/A	N/A
Relative Humidity	-	N/A	N/A
Radiation	-	N/A	N/A

Sources: (2010). The Gazette of Pakistan Islamabad. The National Environmental Quality Standards for Ambient Air

Similarly hydrocarbon are emitted into the atmosphere by natural biological activity as well as anthropogenic sources such as automobiles exhausts burning of coal, oil, wood and refuse and solvent evaporation. Chronic exposure to current outdoor air pollution levels, to which road traffic emissions are a major contributor, may have even larger impacts on mortality than acute exposure [14]. The effect of ozone on people includes (1) irritation of the nose and throat, (2) increased mucus production and tendency to cough (3) eye irritation and headaches for some [5]. Anthropogenic sources account for about 15% of the total hydrocarbon emissions in the atmosphere. The gases act like a blanket where ever their concentration increases, local concentration increase local heat and increases differences between hotter and colder regions drives weather events in to more extreme ranges [1].

Methane is the major hydrocarbon emitted in to the atmosphere by natural activities such as anaerobic decomposition of organic matter in H2O, soil and sediments by micro organism. Extreme levels of pollution may cause markedly increased mortality rates which refers to the meuse valley fog of 1930 or the London Smog of 1952 [15]. Methane is although non toxic, reduce the amount of oxygen in the air necessary to support life. Methane is usually produced by mining/distribution livestock and landfills. Any type of handling, transportation (Through pipeline or truck delivery) or refinement there are additional methane emissions created for every type of fossil fuel [1]. Even by simply buying/using any fossil fuel whether it is coal natural gas or petroleum, contribute to the most important source of methane emissions in the atmosphere. Manure landfills and open garbage dumping sites are full of organic matter like food scraps, newspaper, cut grass and leaves. Many times new garbage comes in it is pilled over the old garbage often gets trapped in conditions where there is no oxygen (anaerobic) and because of this large amounts of methane is created. Various domestic animals places, open garbage and collection sites in the city and dumping areas around the city are best places to produce methane. Similarly livestock animals create methane emissions in 2 ways. Animals like cows, sheep and goats are examples of ruminant animals and during their normal digestion process they create large amounts of methane. The 2nd way that the livestock create methane emissions is from their manure when cows, pigs and chickens are raised in an industrial. Livestock manure management is done by using large waste treatment systems and holding tanks. In these tanks the manure decomposes but because the tanks are closed there is no oxygen.

When organic matter decomposes an aerobically great quantities of methane are produced [1]. High concentrations of nitric oxide gas may cause an oxygen

deficient atmosphere. The nitric oxide has an ability to react in the body to oxidize hemoglobin to met hemoglobin in the blood. Coma and death can ensue when met hemoglobin levels reach 70%. [16]. The study is also included to check the current status and situation of the people. Most of the people who lived nearby of illegal practices of dumping and burning of garbage take place which suffered excitation, rapid breathing, headache and irritating to the respiratory tract and mucous membranes. Chronic exposure to current outdoor air pollution levels, to which road traffic emissions are a major contributor, may have even larger impacts on mortality than acute exposure [17]. Most of the people of Sohrab Goth also suffered headache, nausea and fatigue due to the exposure of vehicular and industrial emissions. Severe over exposure may cause met hemoglobinemia cyanosis, mental confusion and death. [12]. Most of the air pollutants interfere with the function of blood, which results in detrimental effects on whole body, like hemoglobin that carries oxygen from the lungs to the tissues of the body [18-20].

CONCLUSION

Present study provided last three years status of various gases including green house gases in three different areas of Karachi, their possible effects and highly risk on population health. Most of the people who are the permanent resident of the area from where there are heavy movements of vehicles have a problem of lung injury, nasal irritation, hacking cough and increases fatigue. Proper traffic management plan along with different latest equipment and technology should be installed on needs and urgent basis for short term measurement. It is hoped that responsible and enforcement agencies Environmental Protection Agency, Sindh and other Government and Civic organization will take necessary collective step to reduce atmospheric pollution in Karachi. In addition this data would be used for future monitoring of air pollution and additional research.

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