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Assessment of Air Pollutants in Karachi and Hyderabad Cities and Their Possible Reduction Options

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Abstract: The purpose of this study was to examine the level of particulates and carbon concentrations in the form of carbon dioxide and carbon monoxide in Karachi and Hyderabad cities of Sindh province and to propose possible options for reducing the level of air pollutants. For that, a total of six critical locations each in Karachi and Hyderabad cities were selected for recording and analysis of air pollutants. The air quality parameters were recorded for thirty times in each location using standard instruments. The level of single parameter recording took about ninety minutes as the readings were noted after stability of the values in the instrument. The measured results were also compared with National Ambient Air Quality Standards. It was found from the results that the average level of $PM_{2.5}$ at all locations in Karachi city was almost double than Hyderabad city. The concentration level of CO_2 and CO was found to be more in Karachi than Hyderabad. The level of $PM_{2.5}$ in Karachi and PM_{10} in both cities was found to be two times more than standards. It is concluded that the prevailing air quality in both cities may result in substantial health hazards for the residents if left unmanaged.

Key words: Anthropogenic · Carbon compounds · Greenhouse effect · NAAQS · Particulates

INTRODUCTION

Air pollution is considered as a crucial health issue affecting millions of lives around the world. It adversely affects not only local ecological systems, regional atmospheric chemistry but also global climate [1]. It is ascribed to the large scale urbanization and population growth, which results the increase in traffic, industrialization and energy use that ultimately release the pollutants into the atmosphere [2]. The ambient air pollution is considered to be one of the ten major threats contributing to the global health burden, causing approximately 16% of premature deaths in 2009 and around 3.7 million deaths in 2012 [3]. It is predicted that 3.6 million additional premature deaths will be due to ambient air pollution by the year 2050 [4]. Such condition is expected to become worse in densely populated urban areas and megacities of developing regions [3]. It is because the world's mega cities are unable to meet the prescribed concentration limits of air pollutants. Automobile emission is regarded as the principal source of pollution producing particulate matters (PMs) in most metropolitan cities in the world [5]. Besides automobile emissions, thermal power plants, industries and diffused biomass burning also contribute in urban air pollution [1]. Among pollutants which exceed concentration limits are coarse particulate matters (PM_{10}), fine particulate matter ($PM_{2.5}$), carbon dioxide and carbon monoxide. It is reported that the annual mean concentration of PM_{10} on ambient air pollution has increased by more than 5% between 2008 and 2013 in 720 cities across the world [2].

An extensive growth in population, urbanization and industrialization, together with a great increase in motorization and energy use has been seen in Pakistan during last decades. The country is suffering from deterioration of air quality due to the nonexistence of air quality management systems. Evidence from various governmental organizations and international bodies has I ndicated that air pollution is a significant risk to the environment, quality of life and public health [6].

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Parekh *et al*. [7] assessed the total suspended particulate (TSP) loading in the ambient air of two major cities in Pakistan, namely Karachi and Islamabad. Data for TSP were collected at one site in Karachi and two locations in Islamabad. They found highest TSP loadings in both cities as compared to any other megacity of the world. Ghauri *et al*. [8] revealed that the highest concentrations of carbon monoxide (CO) were observed at Quetta with 14 ppm. The maximum TSP and particulate matter (PM_{10}) levels were observed at Lahore with 996 ug/m^3 and 368 ug/m^3, Quetta with 778 ug/m^3 and 298 ug/m^3 and in Karachi with 410 ug/m^3 and 302 ug/m^3 respectively. The highest levels of air pollutants were recorded at major intersections of the cities, which indicated the correlations with the traffic density. The peak level of pollutants was noted in summer and spring while lowest was observed in winter and monsoon. Shabbir and Ahmad [9] analyzed the status of air pollutant emissions and energy demands of Rawalpindi and Islamabad cities. They found that there was increasing trends of vehicular emissions as well as energy demand in both cities. Ilyas *et al*. [10] evaluated the status of air pollution in Quetta, Pakistan by distributing a questionnaire to estimate the allergic symptoms and exposure to assess the respiratory disorders. A strategic air quality management plan was proposed and also mitigation measures were suggested for reducing air pollutants level and to maintain sustainable development and environmental management in the city. Stone *et al*. [11] studied the level of $PM_{2.5}$ and PM_{10} in Lahore, Pakistan by recording the data from 12 January 2007 to 19 January 2008. The annual average concentration of $PM_{2.5}$ was found to be $194 \pm 94 \mu g/m^3$ and PM_{10} was $336 \pm 135 \mu g/m^3$ in all measured locations of the city.

It is revealed from the literature review that no exhaustive study has been conducted by the researchers in Pakistan except a few individual studies in major cities of Pakistan only with specific parameters. Moreover, the air quality varies over a relatively small scale, since the resulting pollutant concentration in a specific place depends predominantly on local emission sources and atmospheric flow conditions. The flow of air masses in urban environments is typically turbulent and difficult to predict without comprehensive studies and data gathering [2]. In the present study, the concentrations of $PM_{2.5}$, PM_{10}, carbon dioxide (CO_2) and carbon monoxide (CO) were studied in two populated cities of Sindh province, which facilitate deeper understanding of air pollutant level and help to manage the cities properly in future.

MATERIALS AND METHODS

This study was focused to examine the particulates and carbon concentrations in the form of carbon dioxide (CO_2) and carbon monoxide (CO) in Karachi and Hyderabad cities of Sindh province. Karachi (24°51'N and 67°02'E) is located in the south-eastern part of Pakistan on the coast of Arabian Sea. It is the country's largest city with a population of over 14 million. The city is expanding in all directions at a rapid pace. Its climate is subtropical, almost desert-like with scanty rainfall. It has a large industrial base including oil-fired power plants, cement factories, a steel mill, textile plants, two refineries, heavy petrochemical industries and several light industries. There are five major industrial areas in the city, namely Landhi, Korangi, Sindh Industrial Trading Estates, Federal B Area and North Karachi. Hyderabad city (25.367°N and 68.367°E) is the 6^{th} most populous city in Pakistan, according to the 1998 census. It is located on the east bank of River Indus and is approximately 150 kilometers away from Karachi, the provincial capital. Hyderabad has a hot desert climate with warm conditions year-round. Both selected cities of province showing trends of rapid growth in population, automobiles and industrial setup. Figures 1 and 2 exhibited the number of different automobiles plying on the roads of Sindh province including Karachi and Hyderabad cities. The total number of vehicles in Sindh province, Karachi and Hyderabad is about 1.54, 1.22 and 0.07 million respectively [12, 13]. The maximum number of vehicles are cars/jeeps and motorcycles with 0.52 and 0.57 million in Karachi respectively, while in Hyderabad the number of motor cycle are in maximum with 0.02 million. The less number of vehicles were tractors in Karachi and pickups/vans in Hyderabad. It is observed from the data that 79.4% of vehicles in Sindh province are registered in Karachi.

A total of six critical sampling locations each in Karachi and Hyderabad cities were selected for recording and analysis of air pollutants. The selected location names and their assigned codes are given in Table 1. The air quality parameters were recorded for thirty times in each selected location. At each location, approximately ninety minutes time was taken to record the data. The data was noted after the stability of the parameter values in the instrument. The measured results were also compared with National Ambient Air Quality Standards (NAAQS) established by the United States Environmental Protection Agency under authority of the Clean Air Act.

Table 1: Names and codes of sampling locations in Karachi and Hyderabad cities

	Name of Locations			
Sr. #	Karachi	Code	Hyderabad	Code
1	Al-Asif Square	K101	Hyderabad By-Pass	H201
2	North Nazimabad	K102	Nasim Nagar	H202
3	Star Gate	K103	City Gate	H203
4	Maripur Road	K104	Station Road	H204
5	Korangi Crossing	K105	Badin Stop	H205
6	National Refinery Chorangi	K106	SITE Area Hyderabad	H206

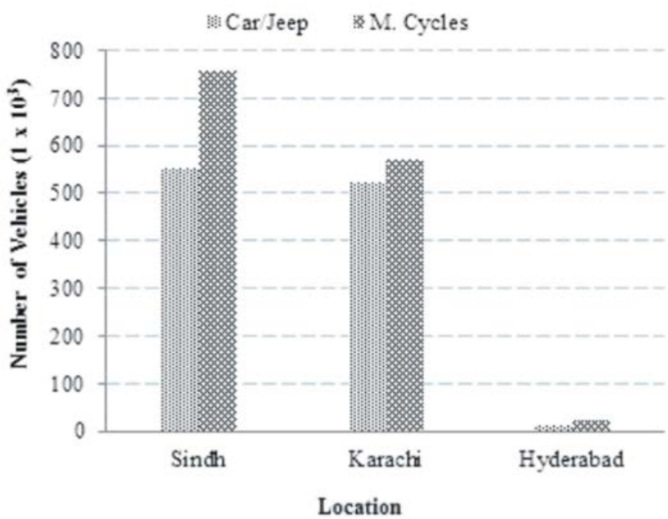

Fig. 1: Number of cars and motor cycles in Sindh province

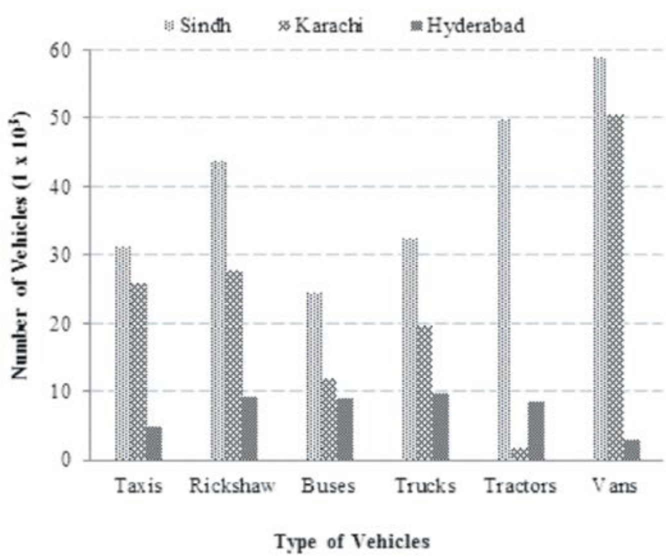

Fig. 2: Number of different types of vehicles in Sindh province

RESULTS AND DISCUSSIONS

The results of recorded parameters were tabulated and analyzed through SPSS software. The minimum, maximum and mean air pollutants level reordered at different selected locations in Karachi and Hyderabad cities are given in Table 2 and Table 3 respectively. The average concentration level of selected air pollutants at different locations versus standards are illustrated in Figures 3 and 4.

Table 2: Concentration level of air pollutants at different locations in Karachi city

Location	Description	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO_2 (ppm)	CO (ppm)
K101	Min	65	288	413	10
	Max	104	353	433	12
	Mean	81	326	423	11
K102	Min	62	271	400	10
	Max	83	323	440	12
	Mean	71	293	418	11
K103	Min	62	194	395	8
	Max	81	257	426	11
	Mean	68	228	413	10
K104	Min	86	308	409	10
	Max	114	364	439	14
	Mean	102	334	425	12
K105	Min	55	230	400	10
	Max	72	269	433	12
	Mean	63	250	418	11
K106	Min	77	274	401	9
	Max	124	311	434	12
	Mean	96	289	419	11
NAAQS Level		35	150	397	9

Table 3: Concentration level of air pollutants at different locations in Hyderabad city

Location	Description	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO_2 (ppm)	CO (ppm)
H201	Min	71	289	393	3
	Max	94	425	426	5
	Mean	85	336	409	4
H202	Min	31	206	386	3
	Max	45	277	411	5
	Mean	39	240	409	4
H203	Min	26	303	391	4
	Max	51	399	419	7
	Mean	40	343	409	5
H204	Min	21	212	388	6
	Max	47	452	431	11
	Mean	37	292	411	9
H205	Min	25	218	370	7
	Max	46	360	429	12
	Mean	39	295	414	9
H206	Min	28	227	396	9
	Max	48	341	422	12
	Mean	39	300	409	10
NAAQS Level		35	150	397	9

The highest concentration of $PM_{2.5}$ in Karachi city was found from the location K104 with 102µg/m^3 and minimum from K105 with 63µg/m^3. Similarly, the highest concentration of $PM_{2.5}$ in Hyderabad city was found from the location H201 with 85µg/m^3 and minimum from H204 with 37µg/m^3. Likewise, the highest concentration of PM_{10} in Karachi city was found from the location K104 with 334µg/m^3 and minimum from K103 with 228µg/m^3, whereas, the highest concentration of PM_{10} in Hyderabad city was found from the location H203 with 343µg/m^3 and minimum from H202 with 240µg/m^3.

The highest concentration of CO_2 in Karachi city was found from the location K104 with 425ppm and minimum from K103 with 413ppm. Similarly, the highest concentration of CO_2 in Hyderabad city was found from the location H205 with 414ppm and minimum were noted from four locations such as H201, H202, H203 and H206 with 409ppm. Likewise, the highest concentration of CO in Karachi city was found from the location K104 with 12ppm and minimum from K103 with 10ppm, whereas, the highest concentration of CO in Hyderabad city was found from the location H206 with 10ppm and minimum from two locations, viz. H201 and H202 with 4 ppm.

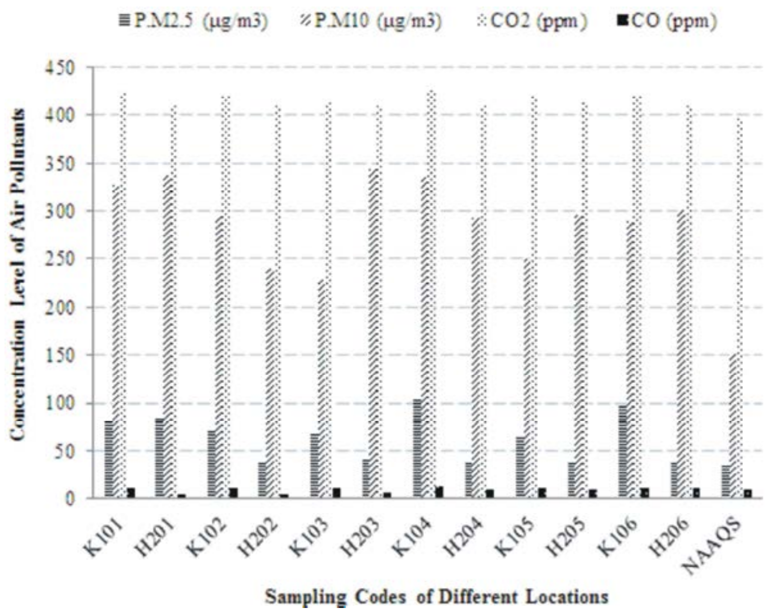

Fig. 3: Average concentration level of air pollutants at different locations

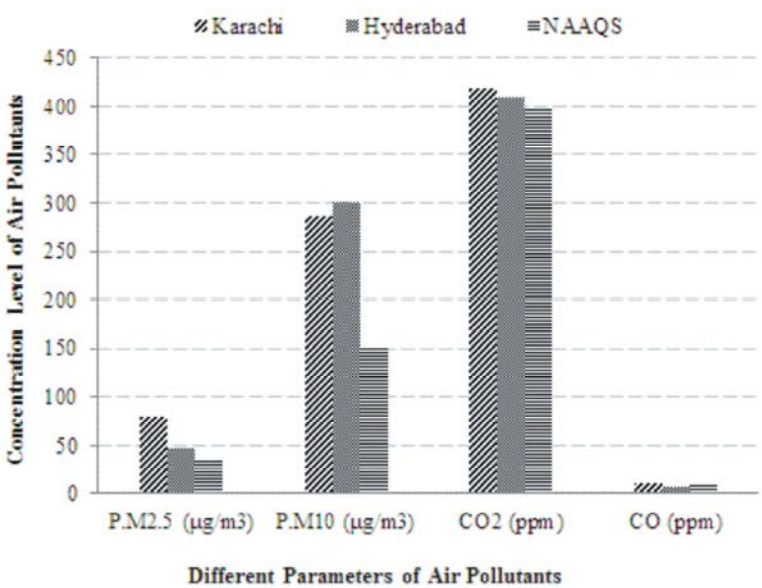

Fig. 4: Average concentration level of air pollutants versus NAAQS

Generally, the maximum concentrations of $PM_{2.5}$, CO_2 and CO were recorded from K104 at Maripur Road and PM_{10} from H203 at City Gate location. The minimum concentrations were noted at H204 for $PM_{2.5}$, at K103 for PM_{10}, whereas, four locations such as H201, H202, H203 and H206 showed similar mean minimum concentrations for CO_2 and two locations, viz. H201 and H202 for CO. It was also observed that the level of $PM_{2.5}$, PM_{10} and CO_2 all observed locations of both cities were more than NAAQS and the level of CO was found to be higher at four locations of Karachi viz. K103, K104, K105 and K106 and one location of Hyderabad city at H206 as compared to NAAQS.

Figure 4 shows the average concentration level of air pollutants at all locations of Karachi and Hyderabad cities. The average level of $PM_{2.5}$ at all locations in the Karachi city was almost double and PM_{10} was slightly less than Hyderabad. The concentration of both CO_2 and CO was found to be more in Karachi than Hyderabad. The average level of CO_2 and CO in Karachi was 419µg/m^3 and

11μg/m^3, whereas, in Hyderabad 410μg/m^3 and 7μg/m^3 respectively. In general, the level of CO_2 was almost equal in both cities, whereas, CO concentration in Karachi was found to be more than Hyderabad city. The level of $PM_{2.5}$ in Karachi was two times greater and in Hyderabad it was just more than NAAQS limits respectively. The concentration level of PM_{10} in both cities was found to be two times more than NAAQS guideline values. The level of CO_2 all observed locations was just above guideline values, whereas, CO concentration was less in Hyderabad and in Karachi it was 1.3 times more than NAAQS.

It is revealed from the analysis that the location of Karachi from K102 to K106 for concentration of $P.M_{2.5}$, $P.M_{10}$, carbon dioxide and carbon monoxide are considerable higher than the NAAQS. It is reported that if the ambient air possesses higher concentrations of pollutants than set standards, it causes severe health hazards on human beings. The higher levels of carbon dioxide and carbon monoxide could be the cause of global warming through buildup of these greenhouse gases in the atmosphere. As compared to Karachi, Hyderabad at the moment is a moderately populated city but still it is showing rising trends of air pollutants levels at most of the air sampling locations. However carbon monoxide is not as much higher as it is in case of Karachi but with the passage of time it may definitely rise and contribute in the buildup of greenhouse gases.

Proposed Measures for Reducing Air Pollution: Following measures are recommended for protection and control of air pollution in urban areas at regional level.

Fresh Air Strategies: This strategy aims to launch comprehensive emission control plan which considers various atmospheric disorders, including acid deposition, ozone, fine particles and greenhouse gases. Changing economic structure and optimization of process or technology is also part of this strategy. The economic regulations, pricing of pollution costs, energy efficiency measures and use of renewable energy resources helps to decrease the level of air pollution [14-16]. Moreover, the establishment of regional air quality monitoring networks, modeling and forecast systems and set up of regulations, systems and emergency response mechanisms on photochemical smog and heavy particulate pollution can also be effective measures for reduction of air pollutants.

Future Air Quality: With the rapid economic development and urbanization, the number of vehicles in Pakistan has been increasing quickly in recent years. In megacities of Pakistan, the vehicle emissions are one of the major sources of air pollution. It is also confirmed from the studies that the major cause of air pollution in megacities is shifted from fossil fuel burning to a mix of fossil fuel burning and vehicle emissions. Therefore, the enhancement of vehicle pollution control in megacities is an important measure to improve air quality in the major cities. It is necessary to boost-up the vehicle pollution control through development of public transport, emission control on new vehicles, emission control on inuse vehicles, fuel quality improvements, alternative-fuel and advanced vehicles, which make a long-term sustainable transportation in urban areas. Moreover, the establishment of green transportation system helps to achieve sustainable development of urban transportation. The awareness and guidance of public in selecting more efficient public transportation system and in moving from private vehicle to public transport, especially in the urban areas, will help reduce both motor vehicle travel mileage and pollution emissions. It is also vital to encourage compressed natural gas, liquefied natural gas and other clean alternative fuel vehicles in the public transportation system as well as to stimulate the use of commercialized clean energy vehicles like the hybrid electric vehicles.

Joint Strategy for Reducing Air Pollution: The key pollutants in joint prevention and control of air pollution include sulfur oxides, nitrogen oxides, particulate matter and volatile organic substances. The important industries which are responsible of such emissions include thermal power plants, iron and steel, non-ferrous metals, petrochemicals, cement and chemicals. It is necessary to establish the mechanisms of integrated planning, monitoring, supervision, evaluation and coordination for the joint prevention and control of regional atmospheric pollution. Furthermore, the environmental friendly measures, like energy efficiency improvements, co-generation of heat and power, fuel substitution and integrated coal gasification combined cycle plants result in lower emissions of air pollutants at no additional costs. A smart mix of measures will help to combat climate change and air pollution more cheaply than tackling either issue independently.

CONCLUSIONS

The level of air pollutants were recorded and analyzed for two main cities namely Karachi and Hyderabad of Sindh province. The results revealed that the average level of $PM_{2.5}$ at all locations in Karachi city was almost double than Hyderabad city. The concentration level of both CO_2 and CO was found to be more in Karachi than Hyderabad. In general, the level of CO_2 was almost equal in both cities. The level of $PM_{2.5}$ in Karachi and PM_{10} in both cities was found to be two times more than NAAQS guideline values. The level of CO_2 all observed locations was just exceeding guideline values, whereas, the CO concentration was 1.3 times more than NAAQS in Karachi and less in Hyderabad city.

It is observed during measurements that sometimes the black cloud was formed as smoke due to the emissions of heavy traffic in the atmosphere of Karachi and Hyderabad cities. The existing tall buildings and absence of reasonable tree cover within the city areas cause interferences in the quick dilution and dispersion of the emitted air pollutants. It is concluded that the prevailing air quality in the cities may result in substantial health hazards for the residents if left unmanaged.

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REFERENCES

1 Aggarwal, P. and S. Jain, 2015. Impact of air pollutants from surface transport sources on human health: A modeling and epidemiological approach. Environment International, 83: 146-157.

2. Kumar, P., L. Morawska, C. Martani, G. Biskos, M. Neophytou, S. Di Sabatino, M. Bell, L. Norford and R. Britter, 2015. The rise of low-cost sensing for managing air pollution in cities. Environment International, 75: 199-205.

3. Lim, Y.H., J.H. Kim, S. Bae, H.Y. Park and Y.C. Hong, 2012. Air pollution and symptoms of depression in elderly adults. Environmental health perspectives, 120(7): 1023-1026.

4. McGranahan, G. and F. Murray, 2012. Air pollution and health in rapidly developing countries. Earthscan, pp: 138-143.

5. Xue, Y., W. Pan, W. Lu and H. He, 2015. Multifractal nature of particulate matters (PMs) in Hong Kong urban air. Science of the Total Environment, 532: 744-751.

6. Colbeck, I., Z.A. Nasir and Z. Ali, 2010. The state of ambient air quality in Pakistan - a review. Environmental Science and Pollution Research, 17(1): 49-63.

7. Parekh, P.P., H.A. Khwaja, A.R. Khan, R.R. Naqvi, A. Malik, S.A. Shah and G. Hussain, 2001. Ambient air quality of two metropolitan cities of Pakistan and its health implications. Atmospheric Environment, 35(34): 5971-5978.

8. Ghauri, B., A. Lodhi and M. Mansha, 2007. Development of baseline (air quality) data in Pakistan. Environmental Monitoring and Assessment, 127(1-3): 237-252.

9. Shabbir, R. and S.S. Ahmad, 2010. Monitoring urban transport air pollution and energy demand in Rawalpindi and Islamabad using leap model. Energy, 35(5): 2323-2332.

10. Ilyas, S.Z., A.I. Khattak, S.M. Nasir, T. Qurashi and R. Durrani, 2010. Air pollution assessment in urban areas and its impact on human health in the city of Quetta, Pakistan. Clean Technologies and Environmental Policy, 12(3): 291-299.

11. Stone, E., J. Schauer, T.A. Quraishi and A. Mahmood, 2010. Chemical characterization and source apportionment of fine and coarse particulate matter in Lahore, Pakistan. Atmospheric Environment, 44(8): 1062-1070.

12. Ahmed, Q.I., H. Lu and S. Ye, 2008. Urban transportation and equity: A case study of Beijing and Karachi. Transportation Research Part A: Policy and Practice, 42(1): 125-139.

13. Qureshi, I.A. and H. Lu, 2007. Urban transport and sustainable transport strategies: a case study of Karachi, Pakistan. Tsinghua Science & Technology, 12(3): 309-317.

14. Jakhrani, A.Q., S.R. Samo, S.A. Kamboh, J. Labadin and A.R.H. Rigit, 2014. An Improved Mathematical Model for Computing Power Output of Solar Photovoltaic Modules. International Journal of Photoenergy, pp: 1-9.

15. Jakhrani, A.Q., A.K. Othman, A.R.H. Rigit, S.R. Samo and S.A. Kamboh, 2012. A novel analytical model for optimal sizing of standalone photovoltaic systems. Energy, 46(1): 675-682.

16. Wang, S and J. Hao, 2012. Air quality management in China: Issues, challenges and options. Journal of Environmental Sciences, 24(1): 2-13.