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Pakistan National Ambient Air Quality Standards: A comparative Assessment with Selected Asian Countries and World Health Organization (WHO)

Dr. Mahmood A. Khwaja, Tahira Shams and Qurratulain

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Mailing Address: PO Box 2342, Islamabad, Pakistan.

Telephone ++ (92-51) 2278134, 2278136, 2277146, 2270674-76

Fax ++(92-51) 2278135, URL: www.sdpi.org

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Pakistan National Ambient Air Quality Standards (AAQSs):

A Comparative Assessment with Selected Asian Countries and World Health Organization (WHO)

The present study was a continuation of our ongoing research at Sustainable Development Policy Institute (SDPI) to assess Pakistan National Environmental Quality Standards (NEQSs) in comparison with those of other Asian countries - whether our standards were stringent or relaxed in comparison to other selected Asian countries and/or if these are consistent with WHO ambient air quality standards. Follow up to our earlier reports, on air pollution in South Asia (Khwaja & Khan 2005; Khwaja & Shaheen 2011; Khwaja et al. 2012, 2019 & 2020;) and the comparative assessment of Pakistan national drinking water quality standards (NDWQSs) with 11 Asian countries & WHO (Khwaja & Aslam 2018), this study was an effort to assess the current status of Pakistan National Ambient Air Quality Standards (NAAQSs), compare to those in 13 South and South East Asian countries as well as with WHO AAQSs (Khwaja et al. 2019). The main focus of the study was to highlight the need for reconsideration/revision, towards further improvement in the NAAQSs and their implementation to safeguard public health, especially of children

The comparative assessment carried out is briefly described and discussed in the present report. It is evident from the comparative assessment of AAQSs of selected Asian countries that except for particulate matter (PM_{10}), values of Pakistan AAQSs, if not better, matches well with others countries in SA & SEA. Pakistan AAQSs values for Ozone ($O_{3)}$ & $PM_{2.5}$ are lowest and none of the 3 parameters (CO, SO_2 & NO_2) Pakistan AAQS values highest among the studied countries. Only India (for CO) & Malaysia (for NO_2) AAQS values, respectively are less than that of Pakistan. Six other countries PM_{10} values are same as that of Pakistan.

1. Introduction

Ambient air quality refers to the condition or quality of air surrounding us in the outdoors and the ambient air refers to the atmospheric air in its natural state (typically 78% nitrogen and 21% oxygen, the extra 1% is made up of a combination of carbon dioxide, helium, methane, argon & hydrogen), not contaminated by air-borne pollutants. The closer the air is to sea level, the higher the percentage of oxygen. Generally, carbon monoxide (CO), oxides of nitrogen (NO_2), sulfur dioxide SO_2, ozone (O_3 particulate matter (PM) and Lead (Pb) are considered pollutants of priority concerns regarding ambient air quality and public health. Some other pollutants of concern for ambient air quality and health are dioxins (PCDD), mercury (Hg), cadmium (Cd) and arsenic (As). The characteristics, sources of emission and their specific health effects of these air pollutants on general public & vulnerable population have been briefly described and reported by Khwaja et al. (2019).

Manufacturing processes and the burning of fossil fuels have directly impacted ambient air quality by releasing a high level of chemical pollutants such as carbon monoxide (CO), ozone (O_3), oxides of nitrogen (NOx), sulfur dioxide (SO_2), lead (Pb) and suspended particulate matter - TSP total suspended particulates (TSP) and PM_{10} particulate matter less than 10 µm in diameter (Aziz, 2006). Generally, industries, households, cars and trucks emit complex mixtures of pollutants to the air, many of which are harmful to health. Fine particulate matter has the greatest effect on human health which is aggravated by meteorological conditions and a combination of population dentistry and urbanization. While air pollution is generally considered to be an urban phenomenon, it is becoming a rural problem with the penetration of transport, expansion of industry, open (point/non-point) burning and the rapid spread/growth of brick kilns. Presently, air pollution monitoring and control efforts in Pakistan are both inadequate and tend to be urban-centered. (Khwaja 2005)

Globally, air pollution is estimated to cause about 29% of lung cancer deaths, 43% of COPD deaths, about 25% of ischemic heart disease deaths and 24% of stroke deaths. Particulate matter pollution is an environmental health problem that affects people worldwide, but low- and middle-income countries disproportionately experience this burden (World Health Organization [WHO] 2007). In terms of total disability-adjusted life years (DALYs) lost due to urban air pollution, mortality accounts for an estimated 60 %. Of this, premature adult mortality has the largest portion. Urban air pollution in terms of particulate matter is estimated to cause around 22,000 deaths among adults and 700 deaths among young children, annually. Indoor air pollution causes the deaths of more than 30,000 children per year (World Bank 2006). For children and adults, both short- and long-term exposure to ambient air pollution can lead to reduced lung function, respiratory infections and aggravated asthma. Maternal exposure to ambient air pollution is associated with adverse birth outcomes, such as low birth weight, pre-term birth and small gestational age births. Emerging evidence also suggests ambient air pollution may affect diabetes and neurological development in children. Epidemiological and animal model data indicate that primarily affected systems are the cardiovascular and the respiratory system. However, the function of several other organs can also be influenced (Cohen et al 2005; Huang and Ghio, 2006; Kunzli and Tager, 2005; Sharma and Agrawal, 2005). It is well established and reported that air pollutants contribute to increased mortality and hospital admissions (Kampa & Castanas 2008).

The World Bank has estimated that the mean annual damage to the environment in Pakistan is 6% of GDP, or Rs. 365 billion per annum. Damages from indoor pollution have been estimated at Rs. 67 billion while damage from urban air pollution has been estimated at Rs. 65 billion or about 1% of GDP (World Bank, 2006). The health impact of the winter fog is estimated at 40% of total urban population in Pakistan and about Rs 25.7 billion each year. A study in Pakistan demonstrated that a 40 per cent reduction in rice crop yields was due to the presence of air pollutants (Hameed et al, 2009). A recent study at Sustainable Development Policy Institute by Khalid & Khavar assessed and explored the situation of air pollution in the country and analyzed the role, gaps and hindrances of multiple institutions that were responsible for tackling air pollution (Khalid & Khavar 2019).

2. Pakistan ambient air quality and national ambient air quality standards

Details of “Air Quality Research in Pakistan,” mainly between 2001 and 2018, have been summarized, reviewed and reported by Khwaja et al. (2019).

Air quality management in Pakistan is handled at the national, provincial, and local (district & city) levels. At the national level, Pakistan Environment Protection Agency (EPA) is responsible for setting air quality and emissions standards guidelines and for defining associated systems for monitoring and enforcement. The 2001 National Environmental Action Plan (NEAP) included air pollution in its core programmes. Some key objectives of NEAP such as the introduction of unleaded gasoline and a reduction of Sulphur in diesel, have already been achieved. To consolidate the ongoing and proposed initiatives for the management of urban air quality, the Ministry of Environment (now Climate Change) had developed the Pakistan Clean Air Program - PCAP, which includes short- and long-term measures along with actions marked for the responsible implementing agencies (World Bank 2006).

Provincial EPAs have almost complete authority to handle environment and air quality management of their respective provinces. Among other functions, they implement rules and regulations of the Pakistan Environment Protection Act (PEPA) 1997 and prepare additional legislation as per the needs of the province. PEPA 1997 is the umbrella legislation that also covers general provisions on air quality. (Pakistan EPA, 2006). The cities of Lahore and Karachi in the Punjab and Sindh provinces respectively have been in the forefront in improving urban air quality. Both cities have established Clean Air Commissions involving high-level representatives from the city and national government as well as other stakeholders, headed by the City Mayor (now replaced by the Administrator).

The framework for Pakistan's air quality management (AQM) system dates back to 1993, when the NEQS were developed under the 1983 Environmental Protection Ordinance. Consultations with major stakeholders were initiated in April 1996. In December 1999, the Pakistan Environmental Protection Council (PEPC) approved a revised version of the NEQS, and they became effective in August 2000. The review was justified by the PEPC because some of the original parameters were more stringent than parameters for other countries in South Asia. In 2010, Pak-EPA drafted NEQS for ambient air. The NEQS for ambient air cover several major pollutants – Sulphur dioxide (SO_2), nitrogen oxide (NOx), Ozone (O_3), suspended particulate matter (SPM), $PM_{2.5}$, Lead (Pb), and carbon monoxide (CO). As required by law, prior to submitting the standards for PEPC's review and approval, Pak-EPA published the draft NEQS on its website and requested comments from the public. PEPC approved both the standards in a meeting held on March 29, 2010 and the official notifications in the Gazette of Pakistan were made on November 26, 2010. (Pakistan Gazette 2010/Annex A)

The cornerstone of environmental legislation in the country is he Pakistan Environmental Protection Act (PEPA) which provides a comprehensive framework for regulating environmental protection, including air pollution. PEPA established the general conditions, prohibitions, penalties, and enforcement to prevent and control pollution, and to promote sustainable development. PEPA delineated the responsibilities of the PEPC, Pak-EPA, and provincial EPAs. So, Pakistan Environmental Protection Agency had set ambient air quality standards throughout the Pakistan, which were envisioned to be effective from January the 1st 2012. Pakistan and WHO AAQSs/guidelines are given in Annexes A and B, respectively

3. Comparative Assessment of Pakistan Ambient Air Quality Standards with Some Selected Asian Countries

Khwaja et al. (2019/Annexes 1-32) have compiled and provided the complete lists of AAQSs of Pakistan, selected south, south-east Asian (SA/SEA) and other countries. The same has been referred to for the comparative assessment of Pakistan AAQSs described and discussed in the forgoing pages. Only seven selected ambient air quality parameters (CO, NO_2, SO_2, O_3, Pb, PM_{10} & $PM_{2.5}$) of priority public health concern were further taken up for a comparative assessment with south Asian (Tables 1) and south-east Asian countries (Table 2)) and the countries selected were those for which AAQS value for the same exposure time were accessible. The selected Asian countries included India, Nepal, Sri Lanka, Bangladesh, Bhutan, Cambodia, Thailand, Malaysia, Indonesia, Vietnam, Philippines, Singapore, and China. Moreover, WHO standards were also considered for overall comparison. Tables 1 & 2 show the concerned parameters guideline values in the selected countries. As already mentioned in the preceding pages, the objective of this study was to assess the current status of Pakistan Ambient Air Quality Standards (AAQSs), i.e., whether Pakistan standards were stringent or relaxed in comparison to the other selected Asian countries and/or if these were consistent with WHO ambient air quality standards. The main focus of the study was to highlight the need for reconsideration/revision, towards further improvement in Pakistan National Ambient Air Quality Standards and their implementation to safeguard public health, especially of children.

Table 1 below shows the comparative data of Pakistan Ambient Air Quality Standards (AAQSs) with ***South Asian*** countries.

Table 1: Pakistan and South Asian (SA) countries AAQSs

Parameters (Time Average)	Pakistan	**AAQSs for South Asia Countries (µg/m3)					WHO
		India	Nepal	Sri Lanka	Bangladesh	Bhutan	
Carbon Monoxide (CO) (8 Hrs)	5	2	10000	10000	10	2000	N.A*
Nitrogen Dioxide ($N0_2$) (24 Hrs)	80	80	80	100	N.A*	N.G*	N.A*
Sulphur Dioxide (SO_2) (24 hrs)	120	80	70	80	365	80	125
Ozone (O_3) (1 hr)	130	180	N.G*	200	235	N.G*	150 - 200
Lead (Pb) (Annual)	1	0.50	0.5	N.G*	0.5	N.G*	0.5- 1
Particulate Matter (PM_{10})(24 Hrs)	150	100	120	100	150	100	50
Particulate Matter ($PM_{2.5}$) (24Hrs)	35	60	N.G*	50	65	N.G*	25

N.G Not Given; N.A* Not Applicable (Time Average not same); **Source: Khwaja et al. 2019*

For carbon monoxide (CO), India has the lowest value, followed by Pakistan among all South Asian countries. Pakistan, India and Nepal all have the same standard AA value for nitrogen dioxide (NO_2). Pakistan standard AA value for Sulphur dioxide (SO_2) is only lower than Bangladesh (highest value) but still lower than WHO. India, Sri Lanka and Bhutan share the same AA standard value, whereas Nepal has the lowest value among South Asia countries for Sulphur Dioxide (Table 1). For Ozone (O_3), Pakistan standard value is very low (even lower than WHO) as compare to India, Bangladesh & Sri Lanka. Bangladesh has the highest value of 235 µg/m3 for SO_2 among all the other south Asian countries

In case of Lead (Pb), Pakistan has the same standard AA value as that of WHO but is higher than that of India, Nepal, and Bangladesh (0.50 $\mu g/m^3$). WHO standard value 50 $\mu g/m^3$, for PM_{10} is three times lower than that of Bangladesh and Pakistan AA value (150 $\mu g/m^3$), the highest among studied South Asian countries. For India, Sri Lanka and Bhutan have the same value 100$\mu g/m^3$, for PM_{10} still 2 times higher than WHO (Table 1). For PM2.5 Pakistan has the lowest values (still above WHO (25 $\mu g/m^3$) compare to other South Asian countries (twice that of WHO). Bangladesh has the highest value (65$\mu g/m^3$) for PM2.5, compare to other South Asian countries.

AAQ data of Pakistan and ***South East Asian*** countries is given Table 2 below.

Pakistan AAQS value for CO is lowest compare to the other five SEA countries. Malaysia has the highest, whereas Vietnam and Philippines have the same AAQ Standard value for CO. Pakistan and

China has same standard value for NO_2 Indonesia and the Philippines have same value and is higher standard value than Pakistan. Malaysia has the lowest standard value for NO_2 among studied South East Asian countries. Pakistan, Malaysia and Singapore (lowest value) standard values for SO_2 which are lower than WHO. Indonesia has the highest value, whereas, Cambodia & Thailand have the same AAQS value for SO_2, higher than WHO (Table 2)

Table 2: Pakistan and South East Asian (SEA) countries AAQSs

Parameters (Time Average)	**Pakistan**	****AAQSs for South East Asia Countries (µg/m3)**								**WHO**
		Cambodia	**Thailand**	**Malaysia**	**Indonesia**	**Vietnam**	**Philippines**	**Singapore**	**China**	
Carbon Monoxide (CO) (8 Hrs)	5	20	N.A*	120	N.G*	10	10	10 mg/m^3	N.A*	N.A*
Nitrogen Dioxide ($N0_2$) (24 Hrs)	80	100	N.G*	10	150	N.A*	150	N.A*	80	N.A*
Sulphur Dioxide (SO_2) (24 hrs)	120	300	300	105	365	125	180	50	150	125
Ozone (O_3) (1 hr)	130	200	N.A*	200	253	N.G*	140	N.A*	200	150 - 200
Lead (Pb) (Annual)	1	N.G*	N.G*	N.A*	1	0.5	1	N.G*	0.5	0.5 - 1
Particulate Matter (PM_{10}) (24 Hrs)	150	N.G*	120	150	150	150	150	50	150	50
Particulate Matter ($PM_{2.5}$) (24Hrs)	35	N.G*	N.G*	N.G*	N.G*	N.G*	50	37.5	75	25

N.G Not Given; N.A* Not Applicable; (Time Average not same); **Source: Khwaja et al 2019*

Like South Asian countries, Pakistan also has the lowest AAQ standard value for Ozone, among the studied SEA countries, which is also lower than WHO. Indonesia has the highest, whereas Cambodia, Malaysia & China have the same value for O_3 within the range of WHO standard. Lead AAQS for all studied SEA countries is below WHO. Indonesia and the Philippines have same standard value for Lead as that of Pakistan, but Vietnam and China have lower standard value than these 3 countries. For PM_{10} only Singapore AAQS standard value is same as that of WHO, all the rest of the studied SEA countries (except Thailand), having same value – 3 times higher than WHO (Table 2). Standard value for $PM_{2.5}$ of Pakistan is lowest compare to that of Philippines, Singapore and China but still higher than that of WHO standard value.

It is evident from the comparative assessment of AAQS of 13 Asian countries given in Table 3 that except for PM_{10}, values of Pakistan AAQSs, if not better, matches well with others countries in SA & SEA.

Table 3: Comparative assessment of Pakistan AAQSs with SA & SEA countries**

		Number of countries compared						
Pollutant Types	**PAAQS (µg/m3)**	**Number of countries compared**	**WHO (µg/m3)**	**Pollutant Types**	**PAAQS (µg/m3)**	**Number of countries compared**	**WHO (µg/m3)**	**Pollutant Types**
CO	5	0	9	1	3	2 (India)	10000 (3 Countries)	N.A*
NO2	80	3	4	1	5	10 (Malaysia)	150 (2 Countries)	N.A*
SO2	120	0	7	6	0	50 (Singapore)	365 (2 Countries)	125
PM2.5	35	0	6	0	7	35 (Pakistan)	75 (China)	25
PM10	150	6	0	6	1	50 (Singapore)	150 (7 Countries)	50
Pb	1	2	0	5	6	0.5 (5 Countries)	1 (4 Countries)	1
O3	130	0	8	0	5	130 (Pakistan)	253 (Indonesia)	150

N.A Not Applicable (Average Time is not same); N.G/N. A; Number of countries whose standards is not given or not applicable for the selective parameter; Total number of Countries=13;*

*** Reference/Source: Tables 1-2/Khwaja et al 2019*

Pakistan AAQSs values for Ozone (O_3) & $PM_{2.5}$ are lowest among the studied AAQSs of other 13 SA & SEA countries.

None of the three contaminants, CO, SO_2 & NO_2 , Pakistan AAQS value is highest among the studied countries. Only India (for CO) & Malaysia (for NO_2) AAQS values are less than that of Pakistan.

Six other countries (Bangladesh, Malaysia, Indonesia, Vietnam, Philippines and China) PM_{10} value is same as that of Pakistan. However, this being three times higher than WHO AAQS value, needs to be reconsidered, revised and be assigned a lower value (Table 3).

Similarly, though within WHO AAQSs for Sulphur dioxide (SO_2), Pakistan AAQ standard value is higher than six studied SA SEA countries India, Nepal, Sri Lanka, Bhutan, Malaysia & Singapore and may be revised and a lower value be assigned, as are the SO2 AAQS values, for the above countries.

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Annexex

Annex A

Pakistan Ambient Air Quality Standards

Pollutants	**Average Time**	**Concentration (µg/m3) effective from 1st January , 2009**	**Concentration (µg/m3) effective from 1st January, 2012**
Carbon monoxide	8 hrs	5	5
	1 hr	10	10
Oxides of Nitrogen (NOx)	annual	40	40
	24 hrs	40	40
Oxides of Nitrogen as NO2	annual	40	40
	24 hrs	80	80
Ozone	1 hr	180	130
Sulfur dioxide	annual	80	80
	24 hrs	120	120
Lead	annual	1.5	1
	24 hrs	2	1.5
Particles as PM10	annual	200	120
	24 hrs	250	150
Particles as PM2.5	annual	25	15
	24 hrs	40	35
Suspended Particulate Matter (SPM)	annual average	400	360
	24 hrs	550	500

Source: Pakistan Environmental Protection Agency, 2012 (visited on April 5, 2019)

http://www.mocc.gov.pk/moclc/userfiles1/file/MOC/National%20Environment%20Quality%20Standards/NEQS%20for%20Ambient%20Air.pdf

Annex B

WHO Ambient Air Quality Standards

Pollutant	**Averaging time**	**Maximum Limit Value (µg/m3)**
Sulphur Dioxide (SO_2)	1 hour	500 (10 min)
	24 hours	125
	Year	50
Nitrogen Dioxide (NO_2)	1 hour	200
	Year	40-50
Ozone (O_3)	1 hour	150-200
	8 hours	120
Carbon Monoxide (CO)	1 hour	30 000
	8 hours	10 000
Black Smoke (BS)	24 hours	50 *
Particles <10 µm (PM10)	24 hours	70 **
Lead (Pb)	Year	0.5-1,0

Source: WHO Air quality guidelines, 2005 (Visited on 8th April, 2019)

(https://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf?sequence=1)