International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **11(4),** 7-12, October **(2022)** *Int. Res. J. Environmental Sci.*

An Assessment of Ambient Air Quality for Environment in Kathmandu Valley, Nepal

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Available online at: www.isca.in, www.isca.me
Received 12th December 2021, revised 13th March 2022, accepted 18th July 2022

Abstract

The growing vehicles, road widening activity were increased dust contamination, smokes in atmosphere which affect air quality of Kathmandu valley. It has a concern to improve for environment. The study was on ambient air quality monitored through field and laboratory analyses by using nine different parameters at different locations of Kathmandu valley. The particulate matters, PM_{10} ranged between 127 and 1193µg/m^3 and $PM_{2.5}$ ranged between 23 and 105µg/m^3. The total suspended particles (TSP) at different location ranged between 240 and 1390µg/m^3. These analytical values were higher than National Ambient Air Quality Standard values in Kathmandu. Gaseous pollutants like, SO_2, NO_2, benzene, lead, and ozone were mostly within acceptable levels. These particulate matters value could be minimized. The stable city is recommended to continue the air monitoring system and bring suitable environment along with developmental activities. The construction is being a successful program and makes different changes. These are promoting air quality and environment.

Keywords: Air, Dust, Environment, $PM_{2.5}$, PM_{10}.

Introduction

Air Pollution is in different urban areas of developing countries due to development works along with increased in population, vehicles and industrialization. The number of vehicles, human activities, climate changes is causes for solid particulate matter in the ambient air of Kathmandu valley. The continuous rise in dust, smoke and various toxic gases have threatened our charming existence and well-being[1]. So, the quality of air around us is important for prevention and should control air pollution. In developed countries, air quality management plans have been good. The Ministry of Population and Environment (MOPE) from Nepal government started to investigate air quality[2]. Then a very few studies had been performed. The study is better if it is supported from some related programs.

Sources of air pollution include road traffic emissions, industrial emissions and domestic heating or secondary formation pollutants[3]). Common air pollutants that draw intense concerns include particulate matter (PM), ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs)[6]. PM is a mixture of constituents that are formed by a large range of mechanisms associated with both natural and anthropogenic origins[7]. Exposure to high concentrations of PM increases the risk on health and environment[8,9].

In addition, aerosol particles have an impact on the environment in areas such as visibility and staining of buildings[10-12]. Particulate matter makes pollution which has been found to be a problem in Kathmandu valley[13].

In this study, particulate matters ($PM_{2.5}$, PM_{10} and TSP), SOx. NO_X, benzene, lead, ozone and carbon monoxide (CO) were monitored at study sites. Some systematic studies of air pollution, inventory, monitoring, and air quality assessment have been carried out in Nepal. The monitoring system is expensive. It is important to find ways to monitor urban air quality at low cost with good technical input in urban Nepal[14]. The study provides ambient air quality at different locations of Kathmandu valley.

Objectives: The general objectives of this study are the assessment of air quality level in study sites. This study will be considered as an environmental database for all sites to categorize in three types. i. Compare the ambient air quality as research works in different sites of Kathmandu which is categorized as heavily polluted, moderately polluted and less polluted sites. ii Different possible parameters are taken for comparison.

Materials and methods

The AAQ instruments (Air Sampler, Fine Particulate Sampler, Envirotech APM 550).

Study Area: Kathmandu valley comprises three districts - Kathmandu, Lalitpur and Bhaktapur. Kathmandu is the study sites (Figure-3). The flow of air is natural in environment. Monitoring sites were selected on the basis of flow of vehicles, people.

Figure-1: Bhudhanilkantha, Less Polluted.

Figure-2: Koteshwor, Heavily Polluted Sites.

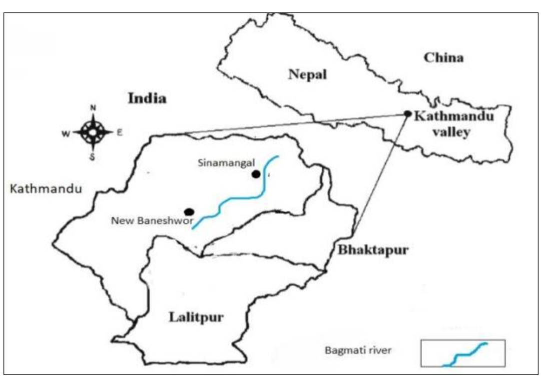

Figure-3: Map showing location of air quality monitoring site.

Figure-4: Kalanki, Heavily Polluted Sites, Construction.

Figure-5: City; Koteshwor, Heavily Polluted Study Site.

Table-1: Description of Air Quality Monitoring Sites in Kathmandu Valley, Figure-3, 4 and 5.

Study Sites	Site Name	Characteristics
Heavily Polluted	Koteshwar	Urban area, Road construction
Heavily Polluted	Ratnapark	Urban areas
Moderately Polluted	Budhanilkantha	Road construction
Polluted and Less Polluted	Kalanki, Near Tribhuvan University Area, Kirtipur	Road construction, Bus park, more flow of vehicles and people in Kalanki. University area, less flow of vehicles and movement

Air Quality Monitoring: Study of Ambient Air Quality of different sites was carried in March 2018. The study was completed from Water Engineering and Training Centre P. Ltd., (WETC), Kathmandu, Nepal. Nine different parameters *viz.* total suspended particulate, PM_{10}, $PM_{2.5}$, SO_2, NOx, Benzene, CO, Ozone, and Lead of study sites were measured (Table-2,3). Sampling was carried out for 24 hours (1^{st} week of March of 2018). Average value was carried out; compare this value with NAAQS for Nepal. For the determination of TSP, PM_{10}, $PM_{2.5}$ and Lead samplings were done with the help of APM 550 Air Sampler. After sampling safely transported to laboratory and taken the weight of exposed filter paper and cup and finally determined the PM_{10} and TSP against the drawn volume of air.

For determination of lead exposed filter paper was digested in nitric acid and determined the lead concentration in AAS (Atomic Absorption Spectrophotometer). SO_x and NO_x were sampled (Figure-1,2). Sodium hydroxide and tetra chloro mercurate (TCM) solutions used for NOx and SOx. The collection tubes, sample were stored in cold condition till analysis of the parameters. For sampling of Benzene Organic Vapor Sampling equipment and activated charcoal tubes were used. After safe transportation of samples to the laboratory, concentration in GC (Gas Chromatography) was determined. For monitoring of Carbon monoxide a dragger pump with low concentration CO detector tube was used in premises.

Results and discussion

During the present study, levels of the ambient air pollution were studied at different sites. The measured values of following parameters presented in Table-2, 3. The PM_{10} ranged from 127-507μg/m^3. Maximum value of PM_{10} (507μg/m^3) was recorded in Kalanki. Values are higher than NAAQS value (120μg/m^3) (Table-1). Particulate matter as PM_{10} are affected the health and environment. The concentration of PM_{10} was recorded 336μg/m^3/24h at Budhanilkantha and 620μg/m^3/24h at Kalanki[15] which was higher than the value of present study. The PM_{10} value in the Kathmandu valley at Ratnapark is presented 133μg/m^3/24h [15].

The value of $PM_{2.5}$ was below the range of NAAQS value (40μg/m^3) at Budhanilkantha, while the range is high in other three sites, Kalanki, Koteshwor and Ratnapark. The $PM_{2.5}$ at Ratnapark in the Kathmandu Valley is presented 47μg/m^3/24h [15] which is less than the value of present study (105μg/m^3) that could be due to construction activity at bus park area as well as haphazard traffic load on the road.

The value of TSP at different sites ranged from 240-1390μg/m^3, maximum value of TSP was recorded at Kalanki (1390μg/m^3). The value of TSP of Kalanki was comparable to the previous year data, which were 1340μg/m^3/24h [15]. The TSP also found higher in range than NAAQS value (230μg/m^3) (Table-4). The value of TSP 212.49μg/m^3 to 467.94μg/m^3 was recorded at Shillong India[19] during April.

The maximum value of TSM in present study was higher than value of Indian cities that could possibly due to road construction activity and traffic load on the road. At present study 24 hours average value of TSP at Ratnapark was recorded 1107μg/m^3 which was higher than from Putalisadak, Kathmandu (728μg/m^3 in 2005 and 687μg/m^3 in 2004). The value was higher and increased every year, in the study sites. According to Department of Environment, 24-hour average of TSP was 4,749μg/m^3, average PM_{10} was 2,928μg/m^3, and $PM_{2.5}$ was 226μg/m^3 [15]. Values are higher for particulate matters in Chabahil than in present study sites.

Various factors make values of particulate matter in different sites. The factors as construction, vehicles pollution causes re-suspension of dust in the air of Kalanki, Ratnapark and Koteshwor area.

The acceptable concentration of PM_{10} as 120μg/m^3 per 24 hour (Table-4[21]). Comparison of status of PM_{10}, $PM_{2.5}$ and TSP shows it is not good. Literature shows average PM_{10} in urban areas of Kathmandu valley was high with daily standard level[13]. High particulate matter pollution found in present study in winter (March). The 24 hour average concentrations of SO_2, NOx, CO, O_3, and lead were also measured together with particulate matters. The 24 hour average concentration of SO_2 measured <0.02 at all sites (Table-3).

This clearly shows that the level of SO_2. The average value of NOx ranged from 0.3 to 9.4. The maximum value (9.4μg/m^3) of NOx was recorded at Ratnapark; though it was lower than the NAAQS values. The 24 hours average concentration of lead was <0.002μg/m^3 at all sites. The value of lead was also lower than the NAAQS. The average value of benzene was measured <2.0μg/m^3 at all sites; while the average value of ozone ranged from 31 to 59μg/m^3. Lowest (31.0μg/m^3) value of benzene was recorded at Budhanilkantha and highest (59μg/m^3) at Kalanki. The CO is less than ppm at sites; instrument is able to detect this value which is very less in comparison to the NAAQS level.

Conclusion

Mean concentrations of particulate matters were the highest in Kalanki and Ratnapark. All types of particulate matter ($PM_{2.5}$, PM_{10} and TSP) exceeded the national standards. This air shows availability of dust in the roadsides. Significantly particulate pollution can be decreased with different programs. Gaseous pollutants as SO_2, NOx, lead, benzene and CO were also within NAAQ standards. So these pollutants could be lower with the completion of road construction and proper traffic management in Kathmandu valley. However amount of CO could not be detected by this used technology in study sites. Constructions works have been undergoing with increased in develop activities it causes dust in the roadsides. The Koteshwor, Kalanki area was dust in roads. The road of Kirtipur and Budhanilkantha area belongs as less polluted sites. Koteshwor, Kalanki and

Ratnapark are heavily polluted sites. The completion of work creates clear environment.

Acknowledgement

Author is thankful with the Faculty Research Grants, University Grants Commission, Bhaktapur; Kathmandu, Nepal. My sincere gratitude is for the Nepal Academy of Science and Technology (NAST) by supporting from Ph. D. Fellowship Program. The honorable sincere gratitude is to Metropolitan Traffic Police, Ramshahpath, Kathmandu, and Government of Nepal for providing the field area facility at different branches to keep the instruments during the experiment time in Kathmandu valley.

Abbreviations: AAQ: Ambient Air Quality Monitoring at different sites of Kathmandu Valley, AAS: Atomic Absorption Spectrophotometer, HC: Hydrocarbons, LPM: Liter per minute, m/s: Meter per second, Mg: Miligram, mg/Nm^3: Miligram per normal cubic meter, MOSTE: Ministry of Science, Technology and Environment, ND: Not detected, PM_{10}: Particulate matters less than 10 microns in size, $PM_{2.5}$: Particulate matters less than 2.5 microns in size, SPM: Suspended particulate matters, TCM: Tetra chloro mercurate, TSPM: Total suspended particulate matters, ug: Microgram.

Table-2: Levels of PM $_{2.5}$, PM $_{10}$ and TSP in µg/m^3 at different air sampling sites in Kathmandu valley.

Study Sites	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	TSP (µg/m^3)
Kalanki (Traffic Police Office Building)	507	86.0	1390
Ratnapark (Nepal Electricity Authority compound)	454.0	105.0	1107.0
Koteshwor (Traffic Police Office compound)	229.0	72.0	813.0
Budanilkantha (Police Office compound)	193.0	23.0	248.0

Table-3: Levels of different pollutants other than particulate matters (in µg/m^3) at different sites in Kathmandu valley.

Study Sites	Lead	SO_2	NO_X	Benzene	Ozone
Kalanki (Traffic Police Office Building)	0.002	0.02	0.30	2.0	59.0
Ratnapark (Nepal Electricity Authority compound)	0.002	0.02	9.40	2.0	43.0
Koteshwor (Traffic Police Office compound)	0.002	0.02	0.30	2.0	47
Budanilkantha (Police Office compound)	0.002	0.02	0.30	2.0	31

Table-4: National Ambient Air Quality Standard (NAAQS), 2012, Nepal.

Parameters	Units	Averaging Time	Concentration, Maximum
TSP (Total Suspended Particulates)	µg/m^3	Annual	-
		24-hours	230
PM_{10}	µg/m^3	Annual	-
		24-hours	120
Sulphur Dioxide	µg/m^3	Annual	50
		24-hours	70
Nitrogen Dioxide	µg/m^3	Annual	40
		24-hours	80
Carbon Monoxide	µ/m^3	8 hours	10,000
Lead	µg/m^3	Annual	0.5
Benzene	µg/m^3	Annual	5
PM $_{2.5}$	µg/m^3	24 hours	40
Ozone	µg/m^3	8-hours	157

Table-5: WHO Air Quality Guideline Values[10].

Pollutant	Averaging Time	WHO Guidelines (µg/m^3)
$PM_{2.5}$	Annual mean	10
	24-hour mean	25
PM_{10}	Annual mean	20
	24-hour mean	50
Ozone (O_3)	8- hour mean	100
	1-hour mean	-
Nitrogen (NO_2)	Annual mean	40
	1-hour mean	200
Sulfur dioxide (SO_2)	Annual mean	-
	24- hour mean	20
	10- minute mean	500
Lead (Pb)	Annual mean	0.5
	3- month mean	-
Carbon monoxide(CO)	1- hour mean	30,000
	8- hour mean	10,000

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