Investigations of Baseline Air Quality around the Proposed Yangon Outer Ring Road Construction (Eastern Section) Area in Myanmar

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Abstract. *Road construction projects are often proposed as a solution to traffic congestion and as well as a means of stimulating economic growth. However, the impact of such schemes on air quality is the problem to be tackled, for which modelled impact predictions are needed prior to any road development project. Yangon Outer Ring Road Construction (YORR) (Eastern Section) is one priority project in the master plan of Greater Yangon Region in Myanmar. This study aimed at investigating the baseline air quality in terms of PM_{10}, $PM_{2.5}$, NO_2 and SO_2, in order to predict the expected increased levels arising from the proposed YORR (Eastern Section) project in Myanmar. Continuous air quality measurements of particulate matter (PM_{10} and $PM_{2.5}$) and environmental gases: NO_2 and SO_2 were carried out from 24 January to 2 March 2021 at 5 locations (for 1 week each) around the proposed road construction by using Haz-Scanner Environmental Perimeter Air Station (EPAS). Based on the results, it appears that particulate matter (PM_{10} and $PM_{2.5}$) were usually high (36.49- 84.02 $\mu g/m^3$ and 27.95- 62.32 $\mu g/m^3$, 34.36- 60.45 $\mu g/m^3$ and 22.69- 59.49 $\mu g/m^3$, 15.64- 57.72 $\mu g/m^3$ and 13.78- 43.84 $\mu g/m^3$ and 10.20- 53.01 $\mu g/m^3$ and 8.03- 40.78 $\mu g/m^3$) at all locations, Point-1, 2, 3 and 4 respectively (except Point-5). So, PM emissions need to be controlled during the proposed YORR (eastern section) project. SO_2 concentrations (20.34 - 32.99 ppb) were found to be within the WHO guideline but slightly higher than NEQG (Myanmar) Guideline on some days at all the Points except Point-4. NO_2 concentrations were found to be within the NEQG (Myanmar) Guideline and WHO standard.*

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1. Introduction

Yangon is the biggest city of Myanmar, having the largest population in the country. Its population was reported about 5,244,000 in 2019, with a 1.69% increase from 2018 (United Nations World Population Prospects, 2020). Yangon has experienced rapid urbanization and motorization (using equipment with motors or motor vehicles) as a result of the nation's economic growth. The current ongoing rapid urbanization is putting more pressure on the existing old infrastructures including roads. In order to alleviate such problems, Yangon Regional Government and Japan International Cooperation Agency (JICA) agreed to start a study to prepare a well-thought future vision and strategic urban development plan. To solve the traffic problems, Yangon City Development Committee (YCDC) launched the "Strategic Urban Development Plan of the Greater Yangon" (SUDP) in 2013 with the assistance by JICA, and formulated the "Project for comprehensive urban transport plan of the greater Yangon" (YUTRA). Yangon Outer Ring Road Construction (YORR) (Eastern Section) is the priority project in the aforementioned master plans of Greater Yangon [1]. The project site is located in an area where five townships - Hlegu, East Dagon, Dagon Seikkan, Thanlyin and Kyauttan, lie next to each other.

The development of transport roads plays an important role in economic growth of a country as the roads bring prosperity in the form of continuous supply of goods and services with better transport facilities. However, from the perspective of the environment, broadening of transport roads will create environmental pollution due to increased traffic on road, land use change, air and noise pollution, socio-economic changes and loss of biodiversity [2].

There is ample evidence that construction activities are an important source of particulate matter (PM) into the atmosphere and can have a substantial temporary impact on air quality. Construction activities represented 3.8% of total particulate emissions from open sources in the US in 1976 [3].

Air emissions with particulate matter and trace gases, released by the machineries and equipment used during construction, temporarily affect the local air quality. Off-road diesel equipment is a relevant source of nitrogen oxides (NOx) and particulate matter (PM) emissions [4], [5].

Exposure to sulfur dioxide in the ambient air has been associated with reduced lung function, increased incidence of respiratory symptoms and diseases, irritation of the eyes, nose, and throat, and premature mortality. Children, the elderly, and those already suffering from respiratory ailments, such as asthmatics, are especially at risk [6].

Previous studies on outdoor air quality in Yangon only reported high outdoor levels of acidic gases such as nitrogen dioxide and sulfur dioxide [7], [8]. Although concern on air quality of the city has been growing in Yangon, there is limited information on air pollution [9].

Myanmar is among 15 countries in the world with the worst air pollution. Around the world, 4.2 million people die from air pollution every year, including 22,000 people in Myanmar, according to World Health Organization statistics [10]. Rising levels of air pollution has become a problem in Myanmar due to the various development projects in transportation sector. Until now, little research has been done on air modelling for future predictions in Myanmar. Therefore, more research on the impacts of new road construction projects on air quality is needed in Myanmar.

This study aimed at investigating the baseline air quality in terms of PM_{10}, $PM_{2.5}$, NO_2 and SO_2, in order to predict the expected increased levels arising from the proposed YORR (Eastern Section) project in Myanmar.

2. Methodology

2.1 Study Area

The study area of this research is around the YORR (Eastern Section) project in Yangon, the former capital city and now the biggest center of commerce and trade in Myanmar. Air quality monitoring was carried out at 5 locations one each in the 5 townships (Hlegu, East Dagon, Dagon Seikkan, Thanlyin and Kyauktan) near the YORR alignment region. The YORR (eastern section) project involves new highway road constructions, which have the total length of approximately 49 km, including the construction of 1.28 km long bridge across the Bago River and the frontage road. The study area mapping with the air quality monitoring locations are presented in Fig. 1.

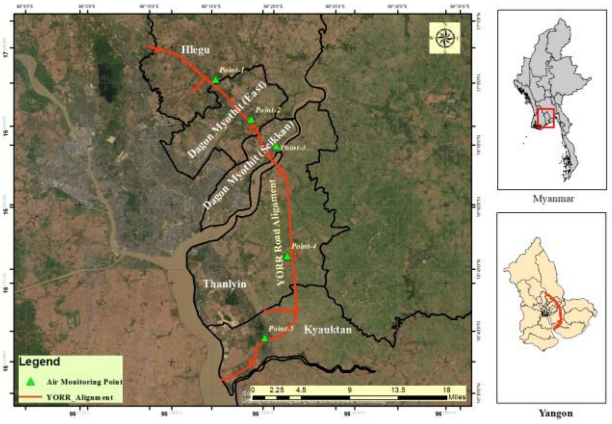

Fig. 1 Map of YORR (eastern section) showing the locations of the air monitoring points

2.2 Air Quality Monitoring and Analyses

Continuous air quality measurements of particulate matter (PM_{10} and $PM_{2.5}$) and environmental gases: NO_2 and SO_2 were carried out from 24 January to 2 March 2021 at 5 locations (Table 1) (for 1 week each) around the proposed road construction by using Haz-Scanner Environmental Perimeter Air Station (EPAS) (Fig. 2 and Fig. 3). The portable HAZSCANNER™ EPAS wireless environmental perimeter air station is easily deployed as an ambient air quality monitor to do continuous measurement of air pollutants (PM_{10}, $PM_{2.5}$, SO_2 and NO_2).

Fig. 2 Checking Data with Piratical Counter

Fig. 1 Installing HAZSCANNER™ EPAS

Sr.	Location	Monitoring Date	Latitude	Longitude	Description
1	Point-1	24-31 Jan, 2021	17° 0' 16.02" N	96° 15' 18.00" E	Hlegu Township (~0.8 km from ROW)
2	Point-2	31 Jan -7 Feb, 2021	16° 57' 2.818" N	96° 18' 10.48" E	East Dagon Township (0.24 km from ROW)
3	Point-3	7-14 Feb, 2021	16° 54' 53.5" N	96° 20' 13.6" E	Dagon SeikKan Township, (~1.9 km from ROW)
4	Point-4	15-22 Feb, 2021	16° 38' 48.37" N	96° 19' 20.32" E	Thanlvin Township, (~0.7 km from ROW)
5	Point-5	23 Feb-2 March, 2021	16°39' 27.5" N	96°19' 15.8" E	Kvaut Tan Township, (~0.51 km from ROW)

*ROW-Right of Way

Table 1 Air Quality Monitoring Locations and Dates

3. Results and Discussions

The measured air quality results for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 at 5 locations is presented in Table 2 and Fig. 4-8. When compared with National Emission Quality Guidelines (NEQG) of Myanmar, International Finance Corporation (IFC) Standards and World Health Organization (WHO) guidelines, concentrations of particulate matters (PM_{10} and $PM_{2.5}$) were usually higher (36.49- 84.02 µg/m^3, 27.95- 62.32 µg/m^3, 34.36- 60.45 µg/m^3; and 22.69- 59.49 µg/m^3, 15.64- 57.72 µg/m^3, 13.78- 43.84 µg/m^3 and 10.20- 53.01µg/m^3 and 8.03- 40.78 µg/m^3 at Points-1, 2, 3 and 4, respectively. PM levels were particularly high at point-1 on all monitoring days. The possible reason for this could be that it is located near the unpaved village access road causing dust erosion. However, PM_{10} and $PM_{2.5}$ levels were usually lower than the NEQG (Myanmar) Guideline, IFC standard and WHO standard on all monitoring days at point-5 which is located far from the existing road.

SO_2 levels were usually lower than WHO guidelines (20.34 - 32.99 ppb), however, were slightly higher than NEQG (Myanmar) guidelines and IFC standards on some week days. NO_2 levels were lower than all 3 guidelines/standards at all monitoring locations.

Location	Days	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2(ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
Point-1	Day-1 (weekend)	**71.44**	**55.15**	30.85	4.49	26.89	41.03
	Day-2	**81.02**	**62.32**	36.47	7.73	28.86	42.64
	Day-3	36.49	**27.95**	22.83	7.67	29.68	45.36
	Day-4	**84.02**	**41.91**	27.47	11.65	30.05	46.44
	Day-5	42.01	**33.88**	30.47	13.59	31.28	47.10
	Day-6	**53.15**	**42.86**	46.27	**20.34**	31.95	46.88
	Day-7 (weekend)	**59.36**	**47.87**	65.86	18.16	30.39	49.04
Point-2	Day-1 (weekend)	34.36	22.69	29.32	8.31	29.57	46.79
	Day-2	46.30	**45.41**	13.14	5.61	29.04	45.45
	Day-3	42.51	**30.56**	13.09	6.61	27.79	45.63
	Day-4	**53.69**	**48.97**	19.91	12.78	29.64	46.44
	Day-5	**54.39**	**59.49**	40.11	17.71	32.88	46.36
	Day-6	**60.45**	**54.07**	43.45	**24.93**	33.26	46.26
	Day-7 (weekend)	39.29	**32.40**	44.05	**30.02**	30.55	48.82
Point-3	Day-1 (weekend)	15.64	13.78	19.57	19.97	31.53	46.38
	Day-2	37.92	**29.84**	4.38	12.73	26.20	47.31
	Day-3	35.09	**26.44**	4.39	16.09	26.81	47.51
	Day-4	**57.72**	**43.84**	9.77	**32.99**	30.43	46.34
	Day-5	41.47	**25.92**	35.66	**20.69**	31.24	46.60
	Day-6	41.62	**26.95**	30.86	**28.54**	31.10	47.45
	Day-7 (weekend)	43.14	**30.49**	17.55	19.86	31.39	47.21
Point-4	Day-1	**53.01**	**40.78**	8.76	13.35	32.09	46.20
	Day-2	39.37	**30.29**	4.19	6.39	29.05	48.27
	Day-3	11.15	9.34	5.18	4.27	31.15	49.43
	Day-4	10.20	9.36	5.61	8.00	31.06	49.18
	Day-5 (weekend)	24.06	17.33	4.08	5.74	31.82	48.44
	Day-6 (weekend)	10.20	8.03	4.31	11.33	34.03	48.09
	Day-7	34.64	24.82	4.07	12.13	32.11	50.72
Point-5	Day-1	4.62	3.69	27.99	**24.38**	30.70	50.28
	Day-2	27.01	22.51	4.82	8.83	24.66	48.08
	Day-3	25.56	21.29	4.59	9.48	24.45	47.92
	Day-4	12.44	10.37	2.87	14.04	24.83	48.14
	Day-5 (weekend)	2.37	1.97	4.04	12.36	24.83	45.59
	Day-6 (weekend)	2.25	1.99	5.44	19.52	26.56	45.88
NEQG (Myanmar) Guideline [11]		1 yr: 20, 24hr: 50	1 yr: 10, 24hr: 25	1 yr: 40, 1hr:200	24hrs:20, 10min:500		
IFC Standard [12]		24hr: 50	24hr: 25				
WHO Standard [13]		1 yr: 20, 24hr: 50	1 yr: 10, 24hr: 25	24hrs:150	24hrs:125		

Table 2 Average Daily Air Quality at 5 Monitoring Points around the Proposed YORR (Eastern Section)

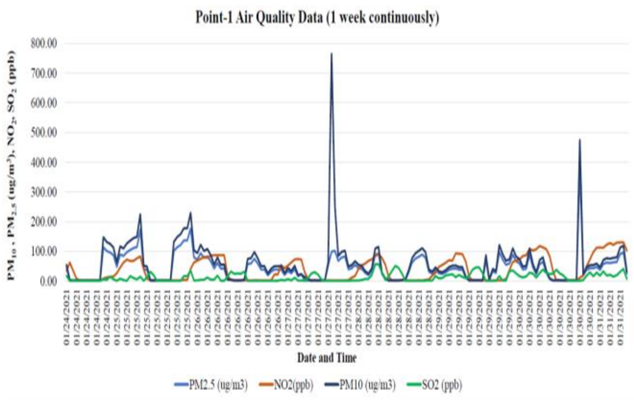

Fig. 2 Air Quality Data at Point-1 (1 week continuously)

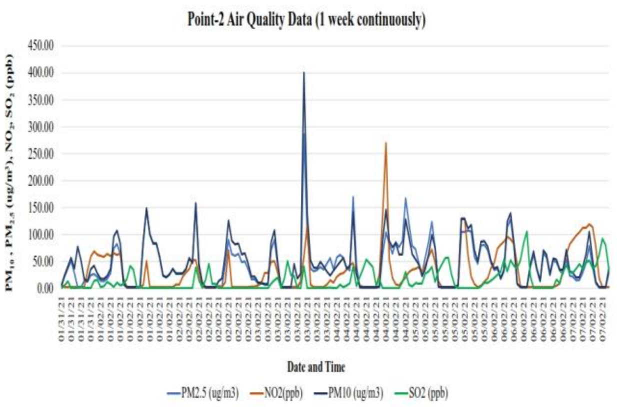

Fig. 3 Air Quality Data at Point-2 (1 week continuously)

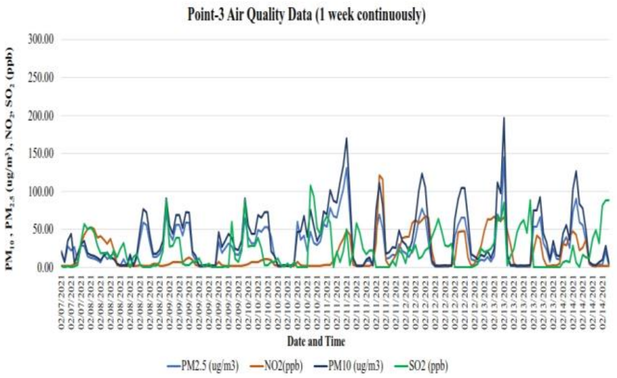

Fig. 4 Air Quality Data at Point-3 (1 week continuously)

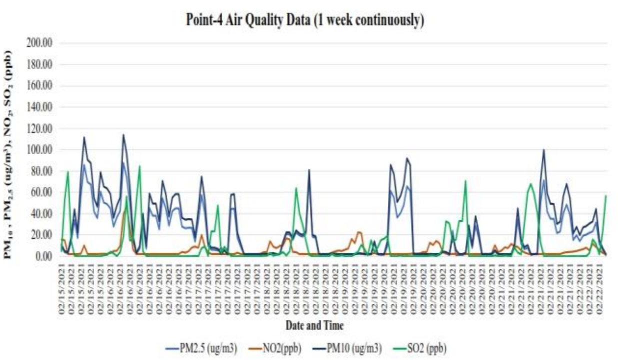

Fig. 5 Air Quality Data at Point-4 (1 week continuously)

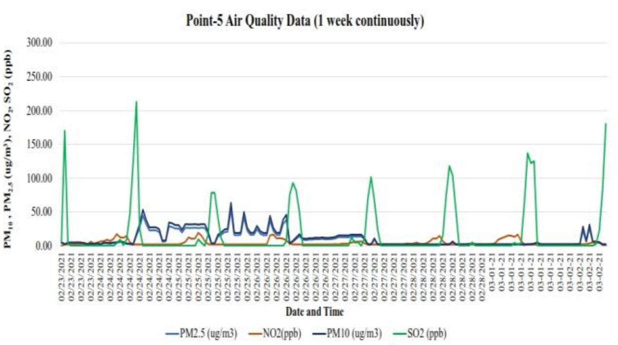

Fig. 6 Air Quality Data at Point-5 (1 week continuously)

The correlations among air quality parameters for each point are shown in Tables 3-7. Particulate matters (PM_{10} and $PM_{2.5}$) have high correlation (>0.7) at all monitoring locations. SO_2 and NO_2 have high correlation (0.89) at point-2. Positive high correlation (>0.7) are found in SO_2 and relative humidity on point-1 and point-2.

Point-1	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	NO_2 (ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
PM_{10} (μg/m³)	1					
$PM_{2.5}$ (μg/m³)	**0.7773**	1				
NO_2 (ppb)	0.0347	0.3224	1			
SO_2 (ppb)	-0.2644	-0.2258	0.6984	1		
Temp (◦C)	-0.4679	-0.5401	0.3086	**0.8660**	1	
RH (%)	-0.4081	-0.5394	0.5193	**0.8466**	**0.8472**	1

Table 3 Correlation among air quality parameters at Point-1

Point-2	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	NO_2(ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
PM_{10} (μg/m³)	1					
$PM_{2.5}$ (μg/m³)	**0.9299**	1				
NO_2 (ppb)	0.2309	0.2508	1			
SO_2 (ppb)	0.2862	0.2597	**0.8902**	1		
Temp (◦C)	0.6564	0.6853	**0.8447**	0.6930	1	
RH (%)	-0.3491	-0.3003	0.6628	**0.7499**	0.2113	1

Table 4 Correlation among air quality parameters at Point-2

Point-3	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	NO_2 (ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
PM_{10} (μg/m³)	1					
$PM_{2.5}$ (μg/m³)	**0.9541**	1				
NO_2 (ppb)	-0.0511	-0.31551	1			
SO_2 (ppb)	0.5535	0.50119	0.3343	1		
Temp (◦C)	0.0026	-0.13944	**0.7563**	0.5999	1	
RH (%)	0.0198	-0.03672	-0.2151	-0.4154	-0.5370	1

Table 5 Correlation among air quality parameters at Point-3

Point-4	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	NO_2(ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
PM_{10} (μg/m³)	1					
$PM_{2.5}$ (μg/m³)	**0.9968**	1				
NO_2 (ppb)	0.4845	0.5328	1			
SO_2 (ppb)	0.4637	0.4557	0.4414	1		
Temp (◦C)	-0.2639	-0.2906	0.0757	0.5696	1	
RH (%)	-0.4531	-0.4919	-0.6882	-0.2719	-0.0976	1

Table 6 Correlation among air quality parameters at Point-4

Point-5	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	NO_2(ppb)	SO_2 (ppb)	Temp (◦C)	RH (%)
PM_{10} (μg/m³)	1					
$PM_{2.5}$ (μg/m³)	**0.9998**	1				
NO_2 (ppb)	-0.2473	-0.2539	1			
SO_2 (ppb)	-0.7487	-0.7520	0.5621	1		
Temp(◦C)	-0.5376	-0.5426	0.5435	**0.9179**	1	
RH (%)	0.2879	0.2805	**0.7156**	0.2743	0.4089	1

Table 7 Correlation among air quality parameters at Point-5

4. Conclusions

Based on the results, it appears that particulate matter (PM_{10} and $PM_{2.5}$) were usually high at Points-1, 2, 3 and 4, respectively (all locations except Point-5). So, PM emissions need to be control during the proposed YORR (eastern section) project. SO_2 emissions were found slightly higher than NEQG (Myanmar) Guideline on some days at all the Points except Point-4. SO_2 were within the WHO guideline. NO_2 levels were found to be within all 3 guidelines/standards at all monitoring locations. Air quality will surely be impacted during the construction period. Therefore, future predictions are required based on the modelling of the observed air quality data for environmental impact assessment.

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References

[1] Japan International Cooperation Agency (JICA), "Transport Master Plans Unveiled for Myanmar and the Yangon Metropolitan Area," 2014 [online] Available: https://www.jica.go.jp/english/news/field/2014/140828 _01.html

[2] P. Banerjee and M. K. Ghose, "Spatial analysis of environmental impacts of highway projects with special emphasis on mountainous area: an overview," *Impact Assessment and Project Appraisal*, vol. 34, no. 4, pp.279-293, 2016.

[3] J. S. Evans and D. W. Cooper, 1980. "An inventory of particulate emissions from open sources," *Journal of the Air Pollution Control Association*; vol. 30, no. 12, pp.298 – 303, 1980 [online] Available: http://dx.doi.org/10.1080/00022470.1980. 10465188.

[4] L. Pirjola, T. Ronkko, E. Saukko, H. Parviainen, A. Malinen, J. Alanen and H. Savelje, "Exhaust emissions of non-road mobile machine: Real-world and laboratory studies with diesel and HVO fuels" *Fuel*, vol. 202, pp. 154–164, 2017.

[5] F. Wang, Z. Li, K. Zhang, B. Di and B. Hu, "An overview of non-road equipment emissions in China" *Atmos. Environ.*, vol. 13, pp. 283–289, 2016.

[6] World Bank Group, "Pollution Prevention and Abatement Handbook: Toward Cleaner Production," 1998.

[7] M. T. H. Ohnamr, H. Yi-Yi, T. S. Than, N. H. Tin, M. A. Myo, A. San and W. San, "Air Quality Monitoring in Selected Sites of Yangon City: a Pilot Study," *Myanmar Health Research Congress*, pp. 4, 2009.

[8] Toe, A. 2009. Air Quality Assessment in Yangon City; Individual Project Report, Air Pollution Management 2009. Advanced International Training Programme. https://www.researchgate. net/Tor_Aung%20Quality_Assessment_in%20Yangon%20City/h tml

[9] W. Y. Aung, M. Noguchi, E. P. Y. Ei, Z. Thanta, S. Uchiyama, T. W. S. Tin and N. Kunugita and OhnMar, "Preliminary assessment of outdoor and indoor air quality in Yangon city, Myanmar," *Atmospheric Pollution Research*, vol. 10, pp. 722–730, 2018.

[10] M. A. Myat, "Beat Air Pollution" on 5 June 2019 [online] Available: https://www.mmtimes.com/news/ beat-air-pollution-june-5.html

[11] Environmental Conservation Department (ECD), "National Environmental Quality (Emission) Guidelines," 2015, [online] Available: https://www.myanmar-responsiblebusiness.org/pdf/2015-12-29-National-Environmental-Quality_Emission_Guidelines_en.pdf

[12] International Finance Corporation (IFC), "Environmental, Health, and Safety Guidelines," *Air Emissions and Ambient Air Quality*, 2007.

[13] WHO, "Air quality guidelines – global update 2005," [online] Available: https://www.who.int/airpollution/ publications/aqg2005/en

Biographies

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