Examining Aerosol Concentrations at Waste Disposal Sites in Lahore, Punjab, Pakistan

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ABSTRACT

The deterioration of ambient air quality and the rise in noise pollution are pressing issues in Pakistan. Open dumpsites and engineered landfills emit various aerosols into the air, potentially causing significant health risks for workers. This study aimed to assess the concentration of aerosols, such as CO_2, CO, NO_2, SO_2, and PM_{10}, in the vicinity of dumping sites situated in Lahore, Pakistan.For the evaluation if temporal variation, the monitoring was done during two seasons i.e. pre-monsoon and post-monsoon. . Pre-monsoon includes the month of March, April and May while post-monsoon includes the month of September, October and November. The ambient air quality monitoring and noise level/quality monitoring was carried out at peak hours. A portable air analyzer, HAZ-Scanner was used for spot monitoring. The readings were noted after 1 minute when the readings became stable. The monitoring was then assessed against the Punjab Environmental Quality Standards. The assessment revealed that the average concentration of monitored parameters CO_2, CO, NO_2, SO_2, PM_{10} in pre-monsoon season was observed to be 493.38±26.11ppm, 14.788±2.536 ppm, 91.64±28.06 µg/m^3, 23.74±3.74 µg/m^3, 383.2±253.8 µg/m^3 respectively whereas in post-monsoon season it was 268.3±35.3ppm, 10.63±3.70 ppm, 61.13±15.41 µg/m^3, 20.250±1.982 µg/m^3, 142.3±56 µg/m^3 respectively. It was found that the air quality was not good during pre-monsoon season while it was satisfactory in the post-monsoon season. Rains play a vital role in the cleaning of atmospheric pollution. In addition to this it was observed that there is direct relationship with the time of the day, traffic load, vehicular emission and emissions from the landfills. There is a need of waste management practices that may help in decreasing the emission level of pollutants in the air. While

transferring the waste, vehicles should be properly covered. During compost formation the sheds must have a pollutant screening hood. It will help to filter hazardous pollutants before releasing into air.

Keywords: Ambient Air, Waste Dumpsites, carbon dioxide (CO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10}), noise level

Introduction

The establishment of metropolitan waste management practices and regularities to cope up with large volume of waste is a key factor for urban waste management *(Verma, Kaur & Tripathi, 2020)*. The waste management authorities have been unable to manage dreadful rise in the degree of urban solid waste *(Verma, Kaur & Tripathi, 2020)*. The city residents have enhanced their quality of living. This has generated a direct correlation between human population and amount of waste *(Chen, 2018; Verma et al., 2020)*. Improper waste management practices have considerable impact on atmospheric contamination *(Okere et al., 2022).*

There are several causes for the discharge of air pollutants at waste dumpsites. Illegal burning of waste, uncontrolled landfill gases, gases erupted due the biodegradation of waste, filth rising from uncovered dumpsites and landfills *(Onwukeme et al., 2021).* These sources are responsible for the release of PM, NO_2, SO_2, CO_2, CO, and polyaromatic hydrocarbons (PAH) in the air at dumping sites *(Onwukeme et al., 2021; Njoku et al., 2019; Iravanian et al., 2020).* It was reported that being underdeveloped countries Pakistan, Bangladesh, Nepal and India are facing highest exposure of particulate matter *(Institute of Health Metrics and Evaluation, 2019).*

A large number of people are living under worst environmental conditions crossing world health organization (WHO) laws in these countries. Since 1990, the air quality of Pakistan has crossed WHO guideline limits. It has remained constantly poor during all three world health organization targets. From past decades Pakistan is facing improper waste management facilities which led to increase in environmental pollution and increase in the human health risks *(IQAir, 2019).*

The uncontrolled colonization of people in the major cities has increased the traffic load and volume of waste which is directly proportional to the release of hazardous pollutants in the ambient air. In Pakistan, there is a lack improper waste management practice in addition to

political unwillingness to lower down the pollutant discharge in air. Due to insufficient resources and irregular transport system the exposure risk to toxins associated illness in the ambient air has been increased tremendously *(Anjum et al, 2021).* In Pakistan, proper engineered landfills are missing. This is the reason that the most common waste disposal method is open dumping of municipal solid waste. Moreover, the major cities of Pakistan like Lahore and Karachi have turned out to be abandoned and neglected platforms of solid waste management. This has decreased the quality of air and public health in the major and small cities in Pakistan *(Sohoo et al., 2022).*

Solid waste dumping sites release a range of pollutants into the ambient air. The disposal sites are sources of the discharge of CO, CO_2, NO_2, and SO_2 in air. This can cause serious human health effects such as cardiovascular diseases, pulmonary infection (Okere *et al.*,2022; Kinoshita, 2020; Anjum *et al.,* 2021) . The emission of gases also effects the environment badly ultimately causes global warming (Prince *et al.,* 2018)

A sustainable waste management can be achieved through incorporation of regular municipal solid waste management practices. On the other hand, developing countries have slower economic growth which directly affects the use of reliable resources for the management practices *(Ravichandran et al., 2021; Yan et al., 2020; Sohoo et al., 2022).* An engineered sanitary landfill requires a continuous monitoring to assess the emission of gases due to biodegradation of waste. Monitoring helps to track pollutant emission and follow the air quality standards *(Nwaokorie, 2018).*

According to the increase in population size, Pakistan has moved to fifth number in the world. It was analyzed during the census report of 2023 the total population of Pakistan is 241.49 million with an expansion rate 2.55%. Lahore being the capital of Punjab reached to 6.3 million of total population *(Worldmeter, 2023).* The unplanned amplification of urban sprawl has created a number of challenges for the management of municipal solid waste. Lack of administrative approach is also one of the reasons for the absence of engineered landfill sites in the Pakistan *(Raza et al., 2021).* Approximately three quarters of solid waste is being collected from metropolitan cities. It has been evaluated that 7690 tons of solid waste is collected on daily basis. A Turkish based company is working in Lahore for collection, transportation and disposal of solid waste to Saggian Bridge disposal station and Lakhodair landfill site *(I.T.A 2022).*

In the light of current scenario, realizing the importance of knowledge on SO_2, NO_2, CO, CO_2, PM_{10} and noise level at open sites and to make an understanding of the possible impacts of open dumpsites on the air quality, this study inquired about the air quality near open dumping sites. The aim was to present appropriate mitigation measurements for enhanced air quality. Mehmood Booti, Saggian Bridge Dumpsite, Lahore Compost Plant and Lakhodair Landfill Site were focused in the current study for the evaluation of environmental quality.

2. Material and Methods

2.1. Study Area

The current study focused on monitoring ambient air quality and noise level monitoring at open dumping sites including Saggian Bridge Dumpsite, Mehmood Booti, Lahore Compost Plant and Lakhodair Landfill Site. These sites were divided into eight sampling points i.e., Saggian Bridge

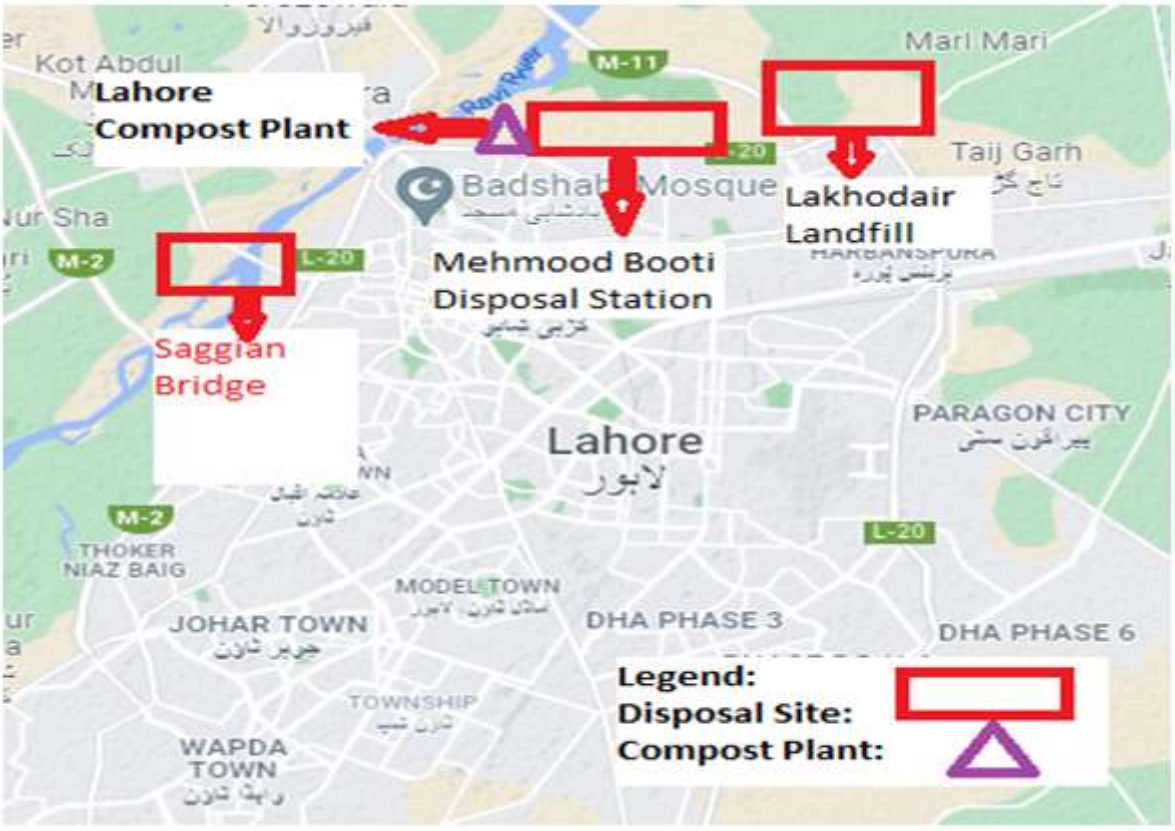

Figure 1: Map of Study Area (Source: Google)

Dumpsite, Waste Disposal Area, Waste Collection Unit, Mehmood Booti, Compost Shed, Screening Unit, Sorting Unit and Lakhodair Landfill Site.

The reason of selecting this area for research was to highlight the direct and indirect effects of waste at open dumping sites on the ambient air and noise levels of the selected areas.

2.2. Sampling Methodology

The study was conducted in two seasons, pre-monsoon and post-monsoon. Pre-monsoon includes the month of March, April and May while post-monsoon includes the month of September, October and November. The ambient air quality monitoring was carried out at peak hours.

During this period regular visits were made to identify the pollutants arising from open dumpsites and their effects on surrounding environment.

2.3. Sampling Size

Total 48 readings of air and noise were taken from eight (08) locations (3 readings from each site). 24 readings of air and noise were measured before Monsoon (Pre-Monsoon) and 24 readings of air and noise were collected after Monsoon (Post-Monsoon).

The monitoring against PM_{10}, CO_2, CO, NO_2 and SO_2 was done for peak working hours between 9:00 AM to 5:00 PM. For monitoring, HAZ-Scanner was used for spot monitoring. The readings were noted at an interval of 1 minute after stabilizing the reading. The final results were compared with the Punjab Environmental Quality Standards.

Haz Scanner, model HIM-6000 is a portable instrument. It is used for spot monitoring. The Haz Scanner is specified for the monitoring of gases like nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone, carbon dioxide, particulates, and VOCs. The calculated readings can be easily seen on the display of the scanner.

2.4.Statistical Analysis

A statistical analysis (standard error mean and standard deviation) was performed by using IBM 25 software. It was done to assess the significant difference between the mean values of pre-monsoon and post-monsoon season.

Table 1: Geographic Coordinates of Sampling Areas

Sr. No.	Sampling Locations	GPS Coordinates	
		Latitude	Longitude
1.	Saggian Bridge Dumpsite	31.56982	74.27141
2.	Waste Disposal Area	31.56976	74.27021
3.	Waste Collection Unit	31.56888	74.26453
4.	Mehmood Booti Dumpsite	31.61090	74.38585
5.	Compost Shed	31.61083	74.38388
6.	Screening Unit	31.61074	74.38368
7.	Sorting Unit	31.61073	74.38357
8.	Lakhodair Landfill Site	31.62985	74.41475

Table 2: Parameters Monitored for Air Quality Analysis

Sr. No	Parameters	Units	Instruments/Methods
1.	PM_{10}	ppm	HAZ Scanner
2.	CO	ppm	HAZ Scanner
3.	CO_2	ppm	HAZ Scanner
4.	NO_2	ppm	HAZ Scanner
5.	SO_2	ppm	HAZ Scanner

Table 1: Ambient Air Quality Analysis at Different Waste Dumping Sites of Lahore

Parameters	Season	Locations							
		Saggian Bridge Dumpsite	Waste Disposal Area	Waste Collection Unit	Mehmood Booti Dumping Site	Compost Shed	Screening Unit	Sorting Unit	Lakhodair Landfill Site
CO_2 (ppm)	Pre Monsoon	453	481.7	457.7	527.7	476.6	499	524.3	509
	Post Monsoon	243.3	247	313.3	275.3	328.3	229.6	247.3	264
CO (ppm)	Pre Monsoon	12.3	14.1	16.3	10.7	14	15.3	18.2	17.4
	Post Monsoon	7	14.6	4	10	11.6	13	13.6	9.3
NO_2 (ppm)	Pre Monsoon	63.3	71	78.7	82.3	68	107.6	138.2	124
	Post Monsoon	43.3	43.6	47.3	60.3	63	74	83	75
SO_2 (ppm)	Pre Monsoon	26	25	22	19	31	24	20.3	22.6
	Post Monsoon	20.3	18.6	16.6	19.6	23	19	21.6	21.6
PM_{10} (ppm)	Pre Monsoon	199	528.6	529	126.3	98	271	837.3	476
	Post Monsoon	95.3	92.6	158.3	115.6	81.3	152.6	215.3	227

Figure 2: (a) *Haz-Scanner* (b) *Spot monitoring* (c) *Mehmood Booti Dumpsite* (d) *Saggian Bridge Dumpsite* (e) *Sorting Unit* (f) *Waste Collecting Unit* (g) *Compost Shed* (h) *Screening Unit*

3. Results & Discussion

The two season (pre-monsoon and post-monsoon) analysis of selected parameters of concern for Ambient Air Quality and Noise Quality in research area shows the respective results reflecting the prevalent picture of ambient air and noise levels at the targeted study area.

3.1. CO_2

The observed value of carbon dioxide was also high at Screening Unit, Lakhodair Landfill and Waste Disposal Area (Figure 3). Due to the degradation of waste large amount of different gases along with carbon dioxide (CO_2) released into air and pollute it. Under suitable environmental conditions, the invigorated organic waste matter undergoes degeneration process which results in the emission of carbon dioxide in the ambient air (Hafeez S. *et.al*, 2021). High levels of carbon dioxide also considered as a root of greenhouse gas which a source of global warming (Musa H.D. *et.al*, 2021: Prince O. *et.al*, 2018).

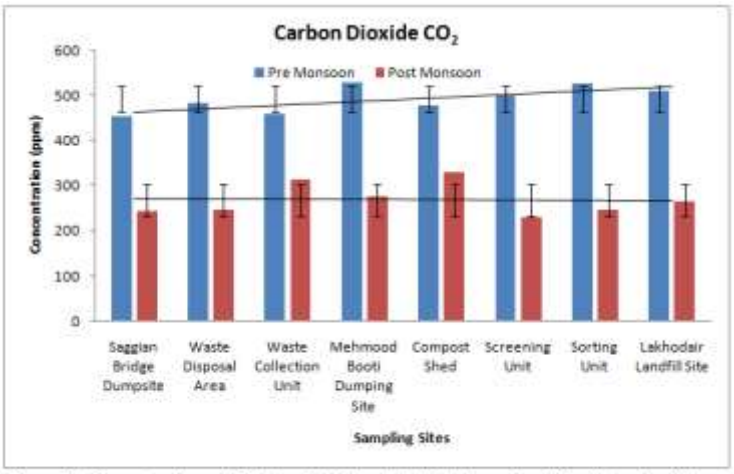

Figure 3: Concentration of Carbon Dioxide at all Eight Sampling Sites (Aug-Sep) Year 2022-23

3.2. CO

The observed value of carbon monoxide (CO) was exceeding the Punjab Environmental Quality Standards at all locations (Figure 4). The concentration of carbon monoxide found in the atmosphere was the result of vehicular emissions. Carbon monoxide gas has no odor. The core sources of CO are vehicles such as waste carrying trucks and heavy machinery that is being used for waste sorting and transfer of solid waste to other units (US-EPA, 2023). The elevated inhalation of CO can be fatal to workers at waste disposal site (Kinoshita. 2020).

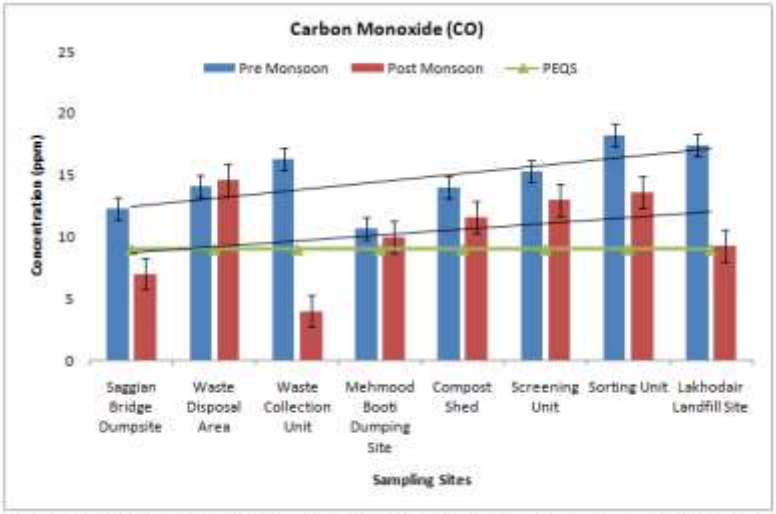

Figure 4: Concentration of Carbon Monoxide at all Eight Sampling Sites (Aug-Sep) Year 2022-23

3.3. NO_2

The concentration of nitrogen dioxide (NO_2) was exceeding the Punjab Environmental Quality Standards (PEQS) (Figure 5). At Sorting Unit and Upside Waste Collection the values were very high. The main sources of NO_2 were the vehicles that collect municipal solid waste and transfer it to the open dumpsite. Burning of solid waste was specific cause of the discharge of NO_2 in air. In addition to this vehicular emission is also a source of NO_2 at the solid waste dumpsite (Anjum M.S. *et.al*, 2021).

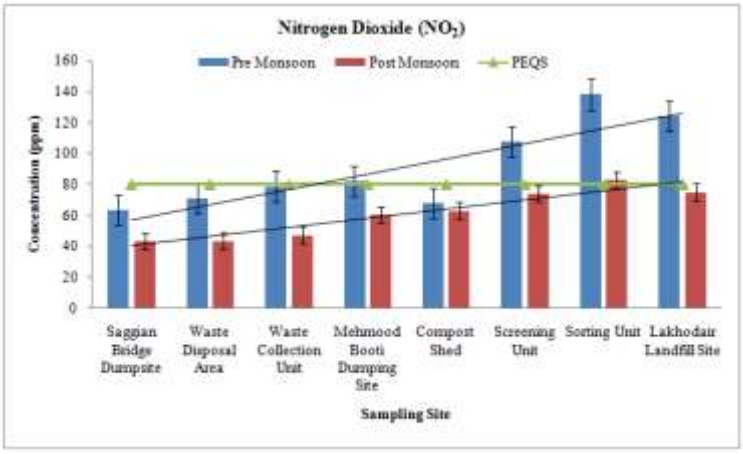

Figure 5: Concentration of Nitrogen Dioxide at all Eight Sampling Sites (Aug-Sep) Year 2022-23

3.4. SO_2

It was observed that throughout the study area the concentration of Sulphur dioxide (SO_2) was very under the standard limits (Figure 6). But it was high at compost shed plant. This happens because composting takes a lot of time for the segregation and sorting of wastes which lead to the increased biodegradation activity of collected waste. Biological degradation and the combustion process are the cause of the release of SO_2 in the ambient air. SO_2 in the air is also responsible for pulmonary distortion (Okere J.K. *et.al*, 2022).

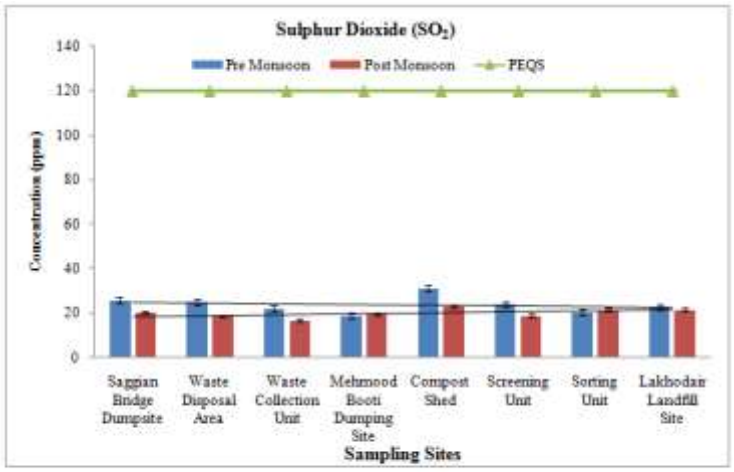

Figure 6: Concentration of Sulphur Dioxide at all Eight Sampling Sites (Aug-Sep) Year 2022-23

3.5. PM_{10}

The concentration of PM_{10} was exceeding the standard limits in many locations (Figure 7). At Sorting Unit, the value was very high. The reason discovered for the high frequency of PM10 at the waste disposal site was deterioration of waste and aging of waste (Okere J.K. *et.al*, 2022)

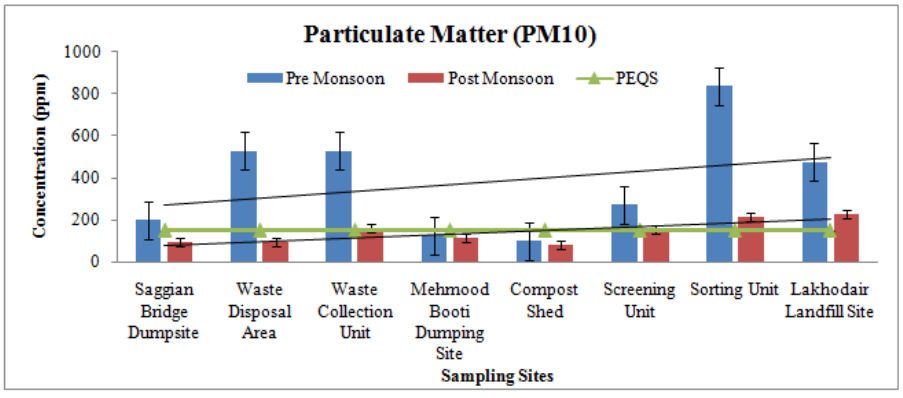

Figure 7: Concentration of Particulate Matter at all Eight Sampling Sites (Aug-Sep) Year 2022-23

In both seasons the average concentration levels of all pollutants were compared. It was monitored that the amounts of CO_2, CO, NO_2 and PM_{10} varied substantially during pre-monsoon and post-monsoon season. The reason was that the level of pollutants decreased in air because it had been lower down by rain. The torrential rainfall during the monsoon season straightens out maximum concentration of air contaminants (Okere J.K. *et.al*, 2022: Markintosh L. *et.al*, 2007). Higher concentration of pollutants was observed in pre-monsoon season due to lower rainfall.

The high concentration of CO, NO_2, SO_2, and PM_{10} causes harmful effects to environment and human health (Okere J.K. *et.al,* 2022: De Giglio O. *et.al,* 2015)). The direct contact to these pollutants can cause injurious health effects such as respiratory illness and cardiovascular diseases (Okere J.K. *et.al*, 2022: Gribben J. *et.al*, 1986).

4. Conclusion

Overpopulation has enhanced the over use of resources like land use and vehicles which is automatically affecting both population and the environment. In developing countries, air pollution has become a serious problem. Increased population has lead to the increased waste generation. This has now become a major source of air pollution in the developing countries. The quality of air was unsatisfactory in the study area. This was due to the high volume of waste, high density of the vehicles and use of compost plant inside the waste dumping site. The main contributor of air pollution was waste collection vehicles and compost producing activities in the study area. Concentration of Particulate matter, carbon dioxide, nitrogen dioxide and carbon monoxide were comparatively high than other pollutant such as sulfur dioxide which was very low.

5. References

[1] Verma N, Kaur M, Tripathi AK. Greenhouse Gas Emissions from Municipal Solid Waste Management Practice. In: Shukla V, Kumar N, editors. Environmental Concerns and Sustainable Development: Volume 2: Biodiversity, Soil and Waste Management. Singapore: Springer Singapore; 2020. p. 399-408.

[2] Chen C, Kotyk JF, Sheehan SW. Progress toward Commercial Application of Electrochemical Carbon Dioxide Reduction. Chem. 2018; 4(11):2571-86.

[3] Okere JK, Abu GO, Azorji JN, Nwachukwu MO, Iheagwam KS, Igwe CE. Evaluation of Ambient Air Quality at Nekede and Naze Dumpsites, Imo State, Southeast Nigeria. Journal of Environmental Treatment Techniques 2022;10(3):195-200.

[4] Eze VC, Onwukeme, VI. Identification of heavy metals source within selected active dumpsites in southeastern Nigeria. Environmental Analysis Health and Toxicology 2021; 36(2):1-18.

[5] Njoku PO, Edokpayi JN, Odiyo JO. Health and environmental risks of residents living close to a landfill: A case study of Thohoyandou landfill, Limpopo province, South Africa. International Journal of Environmental Research and Public Health 2019; 16(2):1-12.

[6] Iravanian A, Ravari SO. Types of contamination in landfills and effects on the environment: A review study. Earth and Environmental Science 2020;614(1):1-12.

[7] HEI HE. State of Global Air 2019, Special Report. Boston; 2019.

[8] IQAir. World Air Quality Report 2019. US; 2019.

[9] IQAir. World Air Quality Report Summary. US; 2023.

[10] Anjum MS, Ali SM, Imad-ud-din M, Subhani MA, Anwar MN, Nizami AS. An Emerged Challenge of Air Pollution and Ever-Increasing Particulate Matter in Pakistan; A Critical Review. Journal of Hazardous Materials 2021; 402:123943.

[11] Sohoo I, Ritzkowski M, Guo J, Sohoo K, Kuchta K. Municipal Solid Waste Management through Sustainable Landfilling: In View of the Situation in Karachi, Pakistan. International Journal of Environmental Research and Public Health. 2022; 19:773.

[12] Kinoshita H, Türkan H, Vucinic S, Naqvi S, Bedair R., Rezaee R.. Carbon Monoxide Poisoning. Toxicology Reports. 2020;7: 169-73.

[13] Tariwari CA, Kariye EL. The spatial and temporal emissions of carbon monoxide (CO) from municipal solid wastes dumpsites in Bayelsa state Nigeria. Medcrave Online Journal of Toxicology 2023;7(1):12-5.

[14] Prince ON, John OO, Olatunde SD, Joshua NE. A Review of Landfill Gas Generation and Utilisation in Africa. Open Environmental Sciences 2018; 10:1-15.

[15] Ravichandran C, Venkatesan G. 3 - Toward sustainable solid waste management – challenges and opportunities. In: Rahman ROA, Hussain CM, editors. Handbook of Advanced Approaches Towards Pollution Prevention and Control: Elsevier; 2021. p. 67-103.

[16] Yan M, Agamuthu P, Waluyo J. Challenges for Sustainable Development of Waste to Energy in Developing Countries. waste Management Research. 2020; 38:229-31.

[17] Nwaokorie KJ, Bareither CA, Mantell SC, Leclaire DJ. The influence of moisture enhancement on landfill gas generation in a full-scale landfill. Waste Management 2018; 79:647-57.

[18] Gondal MS. ANNOUNCEMENT OF RESULTS OF 7TH POPULATION AND HOUSING CENSUS-2023, 'THE DIGITAL CENSUS'. Islamabad; 2023.

[19] Worldmeter. Pakistan Population (live) US: US; 2023 [Available from: http://www.worldmeters.info/world-population/pakistan-population/

[20] Raza ST, Hafeez S, Ali Z, Nasir ZA, Butt MM, Saleem I. An Assessment of Air Quality within Facilities of Municipal SolidWaste Management (MSWM) Sites in Lahore, Pakistan. Multidisciplinary Digital Publishing Institute 2021; 9(9):1-11.

[21] ITA IT. Pakistan - Waste Management US: US; 2022 [Available from: http://www.trade.gov/country-commercial-guides.pakistan-waste-management.

[22] EPAS. Haz Scanner Wireless Perimeter Air Station-EPAS: SKC Inc; 2020 [Available from: https://www.entech.co.th/wp-content/uploads/2020/07/haz-scanner-epas.pdf.

[23] Hafeez S, Ali Z, Nasir ZA, Sultan S. Assessment of Microbial Air Quality within Facilities of Waste Transfer Stations and Disposal Sites of Lahore, Pakistan. Polish Journal of Environmental Study 2021; 30(6):1-10.

[24] Musa HD, Onoja OO, Santali BN. Air Quality Assessment of Solid Waste Dumps in Residential Neighbourhoods. Environmental Technology & Science Journal 2021; 12(1):1-6.

[25] US EPA. Basic Information about Carbon Monoxide (CO) Outdoor Air Pollution US: US-EPA; 2023 [Available from: http://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution.

[26] Markintosh L. Weather plots, temperature and relative humidity, Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York; 2007.

[27] Giglio DO, Quaranta, A, Barbuti G, Napoli C, Caggiano G, Montagna, MT. Factors Influencing Groundwater Quality: Towards An Integrated Management Approach. Annali di Igiene: Medicina Preventiva e di Comunita. 2015; 27(1):52-7.

[28] Gribben J, Hassan SM, Abdullahi ME. Evaluation of Pollutant in Ambient Air: A Case Study of Abuja, Nigeria. International Jornal of Scientist and Research Publications. 2012; 12(2).