International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Air Quality in Buraydah, Saudi Arabia

Abdulaziz S. Alaboodi, Mohammad S. Alshitawi, Ayman F. Omar, Abdulaziz B. Alharby

Abstract: ***Exposure to outdoor and indoor air particles (also known as particulate matter or PM) has attracted the interest of the scientific researchers around the world, this is because of the adverse health effects that particles have on the human. Smaller fractions of particulate matter (repairable range, ≤10 µm) give the greatest health problem, because they have the ability to reach deeper parts of the human respiratory system. Many countries have paid attention to the air pollution and made regulations to improve their indoor and outdoor air quality, Saudi Arabia, particularly Qassim region, has not given much attention to the problem of air contaminants in the ambient and indoor environments. In addition, ambient environmental parameters will be recorded. The results obtained from the indoor and outdoor measurements will help us to evaluate the air quality in Buraydah city for different seasons in the indoor and outdoor environments.***

Keywords: Air Quality; Buraydah; particulate matter; air contaminants.

I. INTRODUCTION

Particulate Matter (PM) is considered the most important pollutants because they contain a complex mixture of organic and inorganic matter which have possible toxic, carcinorgenic, inflammatory, allergenic, and other adverse health effects [1]. Outdoor airborne particles originate from a variety of sources (e.g. road traffic, industry, power plant or domestic combustion, etc.), while indoor particulate matter may originate from outdoors or from sources inside the indoor environments. Epidemiological researches have documented a good relationship between exposure to airborne particulates contamination and respiratory and cardiovascular health problems [2,3,4]. Recent published works have reported that PM is responsible for significant reduction of people life, about 2.1 million of early deaths every year [5,6]. The differences in concentration level, chemical composition, toxicity and solution methods among these sources. Therefore; Ji and Zaho [7] have used a mass-balance model to determine the contribution of different PM2.5 sources to residential buildings in Beijing, China. Another recent study [8] has examined the contribution of indoor and outdoor sources to particulate matter concentration in two mechanically ventilated non-smoking offices in Norway. They have found that the influence of outdoor and indoor (people presence) sources on airborne indoor particles were significant. Custódio et al [9] have conducted experiments to measure simultaneously elemental and organic carbon (EC and OC), and PM10 concentration levels in the ambient air and four selected house in Portugal. They have defined relevant sources of PM in the studied dwellings. Their results showed that ambient air can account for 68% of indoor PM10 which indicated that outdoor air was an important contributor to indoor pollutions. It has been documented [10] that in addition to variation in outdoor particulate matter concentrations, people exposure to PM of ambient origin was also influenced by the degree in which the indoor environments reduce indoor exposures to airborne particles came from outdoor sources. Li et al [11] have reported that 10 µgm-3 increase of outdoor fine fraction is associated with increased obstructive pulmonary disease hospitalizations and death. Outdoor PM and associated chemical species were correlated with short-term and long-term health problems [12]. It has been presented by Nazir et al [13] that the dominant inorganic compounds in the microenvironments and outside environments are Sb, Co, Pb, Fe, and Zn. Poor indoor air quality is related to exiting of a variable collection of microorganisms, such as molds, bacteria and fungi [14]. It has been reported that high concentration levels of bacteria in the indoor environments could rise the probability of epidemics and food contamination and could be responsible for diseases in human respiratory system [15]. Microbes of outdoor origin enter into the indoor areas through natural and mechanical ventilation. In addition, numerous genera of bacteria and fungi are released from indoor sources like domestic animals, flowerpots and wastebaskets [16]. Some researchers were investigating some events (natural and human made) on the air pollution on certain period of year such as after the new year firework or after certain hurricane or any natural disaster producing huge amount of dust. The ambient particulate matter was studied in two European cities during New Year's fireworks [17]. The concentration and the distribution of airborne particles in were measured different cities through different researchers such as Beijing (China) [18], Wollongong (Australia) [19] Newmarket (UK) [20], Uttarakhand (India) [21], Agadir (Morocco) [22] main cities [23] and central and eastern region of Saudi Arabia [24]. One of the application to improve the human breathing zone in polluted are is by introducing a personalized air curtain 25.

Revised Manuscript Received on March 30, 2020.
* Correspondence Author
Abdulaziz S. Alaboodi*, Mechanical Department, College of Engineering, Buraidah 51452, Qassim University, Saudi Arabia. E-mail: alaboodi@qu.edu.sa
Mohammad S. Alshitawi, Mechanical Department, College of Engineering, Buraidah 51452, Qassim University, Saudi Arabia. E-mail: alshitawi@qec.edu.sa
Ayman F. Omar, department, Plant Production and Protection Department, College of Agriculture, Buraidah 51452, Qassim University, Saudi Arabia.
Abdulaziz B. Alharby, Plant Production and Protection Department, College of Agriculture, Buraidah, Qassim University, Saudi Arabia.

Dust storms occur particularly in arid and semi-arid regions. Qassim is considered one of the most influenced regions in Saudi Arabia by these phenomena.

These storms have negative effects on human health in Saudi Arabia. This is because contaminant concentrations are higher during dust episodes. The major ambient pollutant is particulate matter (PM). As it has mentioned before exposure to elevated concentration of PM has been recognized as a significant health problem, particularly in children, elderly and individuals with existing respiratory and cardiac diseases. To the best of our knowledge, no studies have been conducted to investigate particulate matter concentration levels in Qassim region. Understanding the influence of outdoor meteorological parameters, such as temperature, relative humidity, and wind speed on particle concentration is essential. The overall purpose of the research is to investigate airborne particle concentrations for different sizes in the indoor and outdoor environments in Buraydah, Qassim region, Saudi Arabia. The paper focuses on PM2.5, PM10, NO2 and O3 which are the most particulate matter used as representative measure of air pollution. PM2.5 deep penetrated into the human respiratory system due to its small size causing a wide range of health effects. Portable stations equipped with different monitoring devices for particle sampling.

II. CLIMATE AND TOPOGRAPHY OF BURAYDAH

The Buraydah geographical coordinates are 26.326º, 43.975º with elevation of 609 m. The hot season takes 4.4 months, that from May 16 to Sept. 27, with a daily high temperature beyond 39°C. While the cool season takes 3 months, that from November 26 to February 26, with a daily high temperature under 25°C. Figure 1 shows the location of Buraydah at the center to the north of Saudi Arabia.

Figure 1: Map of Buraydah City at the center to north of Saudi Arabia from google map.

In Qassim region there are five station, three of them are located in Buraydah. The three air quality stations in Buraydah are located at the stadium, Zahi Park, and at AlBisr as shown in Figure 2. The distribution of temperature (high and low) during the year are shown in Figure 3. The General Authority of Meteorology and Environmental Protection is responsible for prediction the weather using different stations located in different places on the country. The highest rain falls during one month positioned around January 19, with an average total accumulation of 8 mm. The minimum rain falls around July 2, with 0 mm as shown in Figure 4. The day length varies over the year. The shortest day in Buraydah is Dec. 22, with daylight of 10 hours, 29 minutes while the longest day is Jun. 21, with 13 hours, 48 minutes as shown in Figure 5. The level of comfort humidity is based on the dew point that tends to change more slowly.

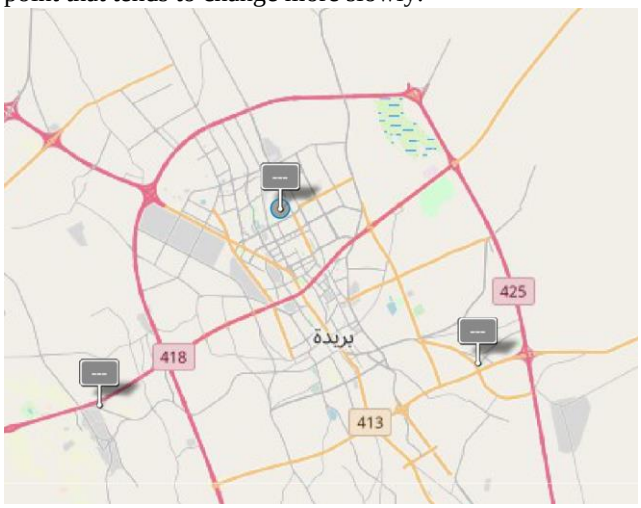

Figure 2: Three air quality stations in Buraydah, at the stadium, Zahi Park, and at Al-Bisr.

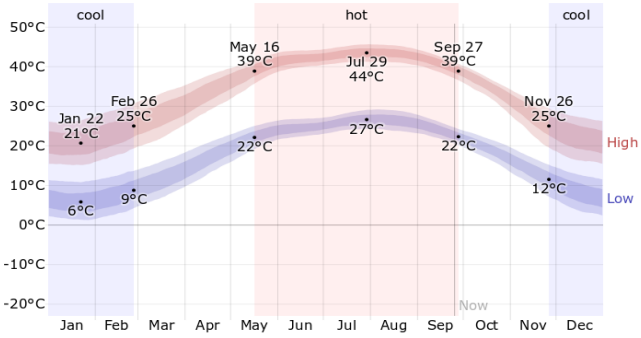

Figure 3: The daily high temperature (red shade line) and low temperature (blue shade line) [27].

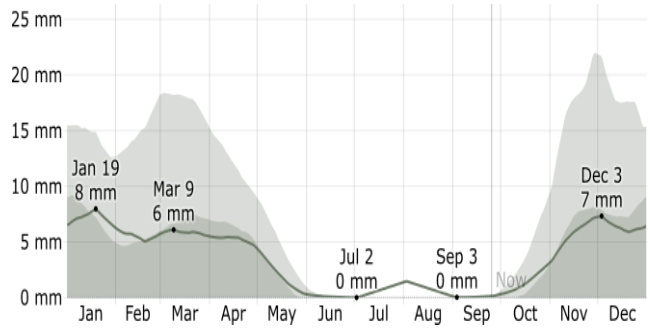

Figure 4: and The rainfall (average) accumulated over one month period [27].

The perceived humidity level in Buraydah, as measured by the percentage of time in which the level of comfort humidity does not differ significantly over the year, which is remaining a virtually constant. For any given location, the wind is dependent mainly on local topography. The wind speed and direction vary more widely than hourly averages. It is measure as the wide-area wind vector hourly average (direction and speed) at 10 meters above the ground of earth. The part of the year high wind speed of about 4.2 m/s in average remains for 6.4 months, that from Jan. 23 to Aug. 2.

However, the part of the year low wind speed of 3.5 m/s in average remain for 5.6 months, from Aug. 2 to Jan shown in Figure 6.

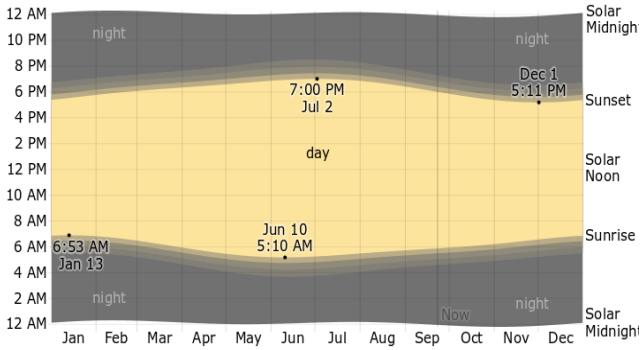

Figure 5: The solar day over the year 2019 [27].

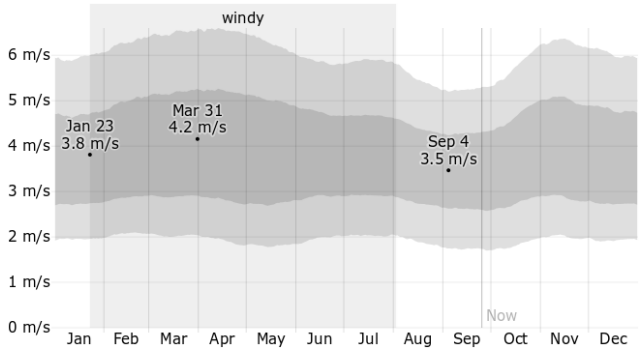

Figure 6: Thee average hourly wind during the year [27].

III. RESULTS AND DISCUSSIONS

For this study, the results of meteorological was used to understand the situation of the air quality of Buraydah. The main particulate substance that affect the air quality in Buraydah city and have been selected to investigated on this study are: Particulate matter (PM10, PM2.5), Ozone (O3) and Nitrogen dioxide (NO2).

Particulate matter (PM2.5, PM10): PM2.5 is particulate matter 2.5 µm or less in diameter, PM10 is particulate matter 10 µm or less in diameter. On the comparison of a human hair which is roughly equal to 100 µm that is approximately 40 time of fine particles width. Particles in the PM10 size range are commonly present in air and may be enter into the body on breathing. It has a direct physical effect and/or be absorbed into the blood. Ozone (O3): The formation of Ozone is when nitrogen oxides react with reactive organic substances air in the presence of sunlight. The sources of organic substances are motor vehicle exhaust, oil refining, petrochemicals and others. Ozone concentrations are approximately constant through the year with small variation with average of 55.3 and standard deviation of 17. Nitrogen dioxide (NO2): The road transport and power plants are the main source of NOx family. It has a direct effect of the O3 production in the troposphere. The life of NOx family is rather short, which is related to the emission sources. The average concentration amount of NO2 during the year 2019 in Buraydah is 18.9 with 8.1 of standard deviation. Figure 8 shows the observed concentrations versus months of six months of year for the four studied pollutants, namely: PM2.5, PM10, NO2 and O3. It shown that PM10 is the highest then PM2.5 then O3 and the least concentration is NO2.

The interesting part is when the concentration reduced and continue with small value at the middle of July. Moreover, the concentration values of PM2.5 and PM10 are higher than the values of O3 and NO2 for the period before the 4th of July and it gets lower after that date as in Figure 7.

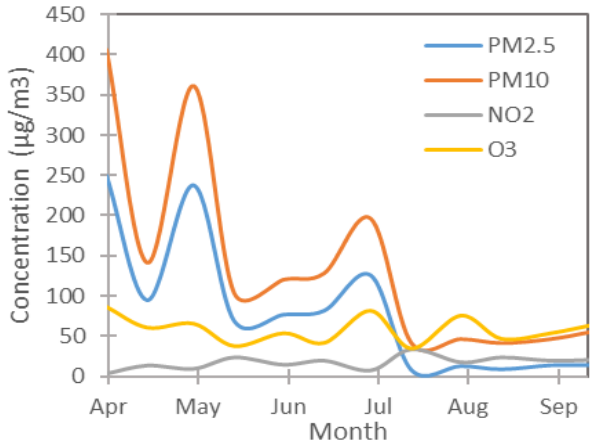

Figure 7: Concentration of main polluted particulate during six months.

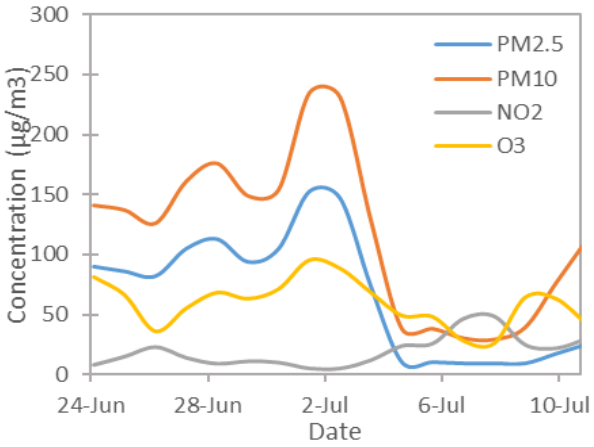

Figure 8: Concentration of main polluted particulate during and 15 days

For more investigation on this region, the sampling was done again for short period of 15 days as shown in Figure 8 It clear that the critical date is the 4th of July which the particulates concentration decrease and remain at low level. While before the 4th of July the concentrations are in high level. Moreover, using short period of days give some strange behavior like some beak on certain time that may not show on the long period of time. Thus, it shown, the beak on the second of July that gives 153, 235, 49, 95 for PM2.5, PM10, NO2, O3 as a maximum reading for the polluted particulate. While at the fifth of July, the reading was 9, 29, 5, 26 for PM2.5, PM10, NO2, O3 as a minimum reading for the polluted particulate. The mean for the period between Jun 24 to July 10 are 66.88, 117.6, 19.7, 59.47 for PM2.5, PM10, NO2, O3 for the polluted particulate as shown in Table 1. The concentration during one day shows the variation between day and night reading. Table **1** show the statistical parameters for the four pollution particulate concentration. The mean of PM2.5, PM10, NO2, O3 are 82.9, 140.3, 17.67, 57.83 respectively.

In addition, the standard deviations are 85.1, 124.0, 8.1, 17.0 respectively. It appears that at the middle of July the four pollution particulate concentration decrease and continue with small value.

The sampling for this chart was taken each 15 days.

Table 1: Statistical parameters of the particulate substance concentration during six months and 15 days.

	Six months				15 days			
Parameters	**PM2.5**	**PM10**	**NO2**	**O3**	**PM2.5**	**PM10**	**NO2**	**O3**
Mean	82.9	140.3	17.7	57.8	66.88	117.6	19.7	59.47
Standard Deviation	85.1	124	8.1	17.0	50.95	66.84	13.18	19.58
Range	242	365	30	52	144	206	44	69
Minimum	8	41	4	34	9	29	5	26
Maximum	250	406	34	86	153	235	49	95
Sum	995	1684	212	694	1137	2000	335	1011
Count	12	12	12	12	17	17	17	17
Confidence Level(95.0%)	54.13	78.79	5.17	10.8	26.2	34.37	6.78	10.07

Figure 9 shows the maximum concentration level for polluted particulate at 12:00 noon. While the concentration at night from 9 pm to 6 am, the concentration approximately remains constant. This has interpretation that the exist and location of sun is affect the concentration of the polluted particulate. On other word, the increase of temperature may effect on increasing the polluted particulate as shown in Figure 9. At the 5th of October, the PM10 increased to reach about 200 µg/m^3 at 12:00 noon, which is means unhealthy air. At that time, a dust blows in the city, after that a short rain came and reduce the dusty weather as shown it reduced to about 50 µg/m^3. It is common during October, the weather has a combination of dusty storms and rain, that the particulate concentrating fluctuating between high and low values.

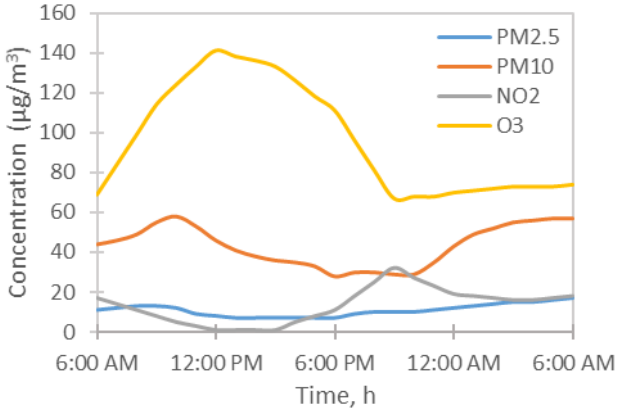

Figure 9: Concentration of main polluted particulate during one day on 1/10/2019

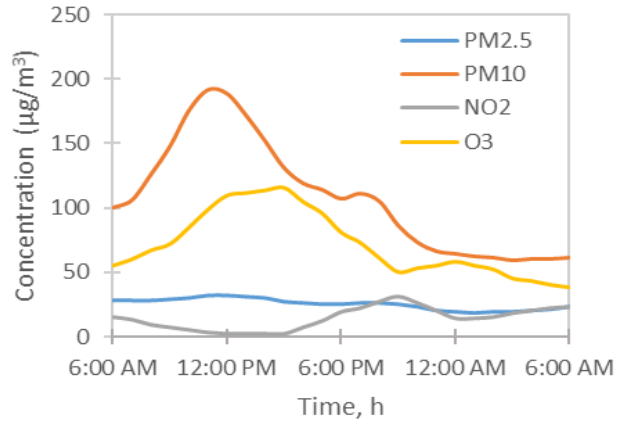

Figure 10: Concentration of main polluted particulate during one day on 5/10/2019

Table 2: Air Quality Index scale, US-EPA 2016 [28]

AQI	PM2.5 (µg/m^3)	Air Pollution Level
0 - 50	0-12	Good
51 -100	12-35	Moderate
101-150	35-55	Unhealthy for Sensitive Groups
151-200	55-150	Unhealthy
201-300	150-250	Very Unhealthy
300+	>250	Hazardous

Table 2 show the air pollution level corresponding to the PM2.5 concentration as the US-EPA 2016 standard. Exposure to PM, especially soft objects such as PM2.5, can cause devastating effects on health, especially on the heart, such as angina or stroke. This increases the crowding of the emergency department in hospitals as well as the increase in the need for health care, and this effect leads to premature death. These compounds are also associated with their harmful effect on the respiratory system, including asthma attacks.

Soft particulate such as the PM2.5 are the main reason of visibility reducing (haze) especially during driving. These compounds can travel over long distances through the wind and then settle on the soil or on the surface of the water. The impact of its settle on the surface are reducing the quality of agricultural soils, as well as damaging the sensitive soil crops as well as affecting biodiversity. In addition, PM can stick and destroy stones or other building materials, which can greatly affect heritage buildings.

From the results It can be Come up with that the increase of PM during summer season due to the sandy storm with the absence of rain during this season makes it remain in the atmosphere. The surrounding areas of Buraydah are arid desert areas that increase the spread of PM. One of the suggested solution to reduce PM inside the city is the establishment of a number of surrounding frescoes large trees that do not need much water with dense of leaves that to disrupt and repel the

movement of PM into the city.

IV. CONCLUSION

In conclusion, this work presents the study of concentration and effect of the main polluted particulate (PM2.5, PM10, NO2, and O3) of air quality on the city of Buraydah, the capital of Qassim region in Saudi Arabia. The data was collected from a ground station through the year of 2019. The results of PM2.5 was compared with the collected between 2000 to 2010. The interesting is that, the year in Buraydah could be divided to two sections. The first is from (March, April. May, June, July) and the second section are the following months (August, September, October, November, December, January, February). The first section with mean of with large PM2.5 with average of 118 while the second with low value with average of 12.5. The average values of PM2.5, PM10, NO2 and O3 are 67.7, 116.18, 18.9 and 55.27 respectively. The indicator of the average of PM2.5 of 67.7 is classified as unhealthy. This situation because of that the dust came time to time on certain period of year that rise the amount of PM2.5 to reach 150 and PM10 to reach 250 $\mu g/m^3$ at the second of July. The short events of non-healthy air quality will increase the average of PM2.5. This lead us to take care of our self and our children on certain periods of year to avoid outdoor activity. Moreover, to double chick of the windows and door.

For the future work, it is necessary to increase the number of particulate monitoring that to give indication of topographical distribution of polluted particulate. More interest should be concern on the dust days to study and investigate the cause and the solution of the problem. The arid and dry weather has a potential of separated the polluted particulate. Thus, the increase of trees inside and around the city will contribute of reducing the amount of polluted particulate. Buraydah surrounded by sandy lands, that used for hiking using auto bicycles or sport cars that increase the dust flows to the city and increase the polluted particulates.

ACKNOWLEDGMENT

The authors wish to thank the scientific research deanship at Qassim University SRD-QU for funding this research.

REFERENCES

1. Jones AP. Indoor air quality and health. Atmospheric environment. 1999 Dec 1;33(28):4535-64.
2. Peng RD, Chang HH, Bell ML, McDermott A, Zeger SL, Samet JM, Dominici F. Coarse particulate matter air pollution and hospital admissions for cardiovascular and respiratory diseases among Medicare patients. Jama. 2008 May 14;299(18):2172-9.
3. Brook RD, Rajagopalan S, Pope III CA, Brook JR, Bhatnagar A, Diez-Roux AV, Holguin F, Hong Y, Luepker RV, Mittleman MA, Peters A. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. Circulation. 2010 Jun 1;121(21):2331-78.
4. Eisner MD, Anthonisen N, Coultas D, Kuenzli N, Perez-Padilla R, Postma D, Romieu I, Silverman EK, Balmes JR. An official American Thoracic Society public policy statement: Novel risk factors and the global burden of chronic obstructive pulmonary disease. American journal of respiratory and critical care medicine. 2010 Sep 1;182(5):693-718.
5. Fantke P, Jolliet O, Evans JS, Apte JS, Cohen AJ, Hänninen OO, Hurley F, Jantunen MJ, Jerrett M, Levy JI, Loh MM. Health effects of fine particulate matter in life cycle impact assessment: findings from the Basel Guidance Workshop. The International Journal of Life Cycle Assessment. 2015 Feb 1;20(2):276-88.
6. Kim, Ki-Hyun, Ehsanul Kabir, and Shamin Kabir. A review on the human health impact of airborne particulate matter. Environment international. 2015; 74: 136-143.
7. Ji, Wenjing, and Bin Zhao. Contribution of outdoor-originating particles, indoor-emitted particles and indoor secondary organic aerosol (SOA) to residential indoor PM2.5 concentrations: A model-based estimation. Building and Environment 90 (2015): 196-205.
8. Chatoutsidou, Sofia Eirini, et al. Indoor/outdoor particulate matter number and mass concentration in modern offices. Building and Environment 92 (2015): 462-474.
9. Custódio, Danilo, et al. Indoor and outdoor suspended particulate matter and associated carbonaceous species at residential homes in northwestern Portugal. Science of The Total Environment 473 (2014): 72-76.
10. Gall, Elliott T., et al. Exposure to particulate matter and ozone of outdoor origin in Singapore. Building and Environment 93 (2015): 3-13.
11. Li, Man-Hui, et al. Short Term Exposure to Ambient Fine Particulate Matter (PM2. 5) Increases. chest 15 (2015): 0513.
12. Wild, P., Bourgkard, E., Paris, C. Lung cancer and exposure to metals: the epidemiological evidence. Method Mol. Biol. 472 (2009): 139–167.
13. Nazir, Rashida, Nazia Shaheen, and Munir H. Shah. Indoor/outdoor relationship of trace metals in the atmospheric particulate matter of an industrial area. Atmospheric Research 101.3 (2011): 765-772.
14. Fabian, M.P., Miller, S.L., Reponen, T. and Hernandez, M.T. Ambient bioaerosol indices for indoor air quality assessments of flood reclamation. Aerosol Science 36 (2005): 763-783.
15. Aydogdu, H., Asan A., and Otkun, M.T. Indoor and outdoor airborne bacteria in child day-care centers in Edirne City (Turkey): seasonal distribution and influence of meteorological factors. Environ. Monit. Assess. 8 (2008):76-89.
16. Yassin, M.F. and Almouqatea, S. Assessment of airborne bacteria and fungi in an indoor and outdoor environment. International Journal Environmental Science and Technology 7 (2010): 535-544.
17. Tanda, Stefan, Roman Ličbinský, Jitka Hegrová, and Walter Goessler. Impact of New Year's Eve fireworks on the size resolved element distributions in airborne particles. Environment international 128 (2019): 371-378.
18. Shi, Zong-bo, Ke-bin He, Xue-chun YU, Zhi-liang YAO, Fu-mo YANG, M. A. Rui, Ying-tao JIA, and Jie ZHANG. Diurnal variation of number concentration and size distribution of ultrafine particles in the urban atmosphere of Beijing in winter. Journal of Environmental Sciences 19, no. 8 (2007): 933-938.
19. Dominick, Doreena, Stephen R. Wilson, Clare Paton-Walsh, Ruhi Humphries, Elise-Andree Guérette, Melita Keywood, Dagmar Kubistin, and Ben Marwick. Characteristics of airborne particle number size distributions in a coastal-urban environment. Atmospheric Environment 186 (2018): 256-265.
20. Davison, Joshua A., Claire E. Wylie, Charles E. McGladdery, Connor Fettes, Emily F. Haggett, and Pieter HL Ramzan. Airborne particulate size and concentrations in five Thoroughbred training yards in Newmarket (UK). The Veterinary Journal 248 (2019): 48-50.
21. Joshi, M. and Srivastava, R.K. Identification of indoor airborne microorganisms in residential rural houses of Uttarakhand, India. Int.J.Curr.Microbiol.App.Sci. 2 (2013): 146-152.
22. Ajdour, A., R. Leghrib, J. Chaoufi, A. Chirmata, L. Menut, and S. Mailler. Towards air quality modeling in Agadir City (Morocco). Materials Today: Proceedings (2019).
23. Munir, Said, Safwat Gabr, Turki M. Habeebullah, and Mamoun A. Janajrah. Spatiotemporal analysis of fine particulate matter (PM2. 5) in Saudi Arabia using remote sensing data. The Egyptian Journal of Remote Sensing and Space Science 19, no. 2 (2016): 195-205.
24. Mashat, AW.S., Alamoudi, A.O., Awad, A.M. Mazen E. Assiri. Synoptic characteristics of dusty spring days over central and eastern Saudi Arabia. Air Qual Atmos Health (2017) 10: 307.
25. Alshitawi, Mohammed Saleh, S. Suyambazhahan, and Abdulaziz S. Alaboodi. Computational fluid dynamics simulation of breathing zone of the human for air quality with a personalized air curtain. Advances in Mechanical Engineering 11, no. 5 (2019): 1687814019844688.

26. https://air.plumelabs.com/air-quality-in-buraidah-rUI
27. https://weatherspark.com/y/102734/Average-Weather-in-Buraydah-Saudi-Arabia-Year-Round
28. https://www.epa.gov.

AUTHORS PROFILE

Prof. Abdulaziz S. Alaboodi completed his PhD from King Fahd University for Petroleum and Minerals, Saudi Arabia. He is a Professor at Qassim University. He has over 40 Multi-national Journal and Conference papers to his credit.

Dr. Mohammed Alshitawi completed his PhD from University of Reading, UK. He is an assistant professor at Qassim University. He has over 12 Multi-national Journal and Conference papers to his credit.

Prof. Ayman F. Omar His major is phytoplasma diseases. diagnoses and identification the phytoplasma groups and sub-groups. He uses the molecular methods for diagnoses and identification the phytoplasmas. Since 2015 he has worked in Qassim university, faculty of agriculture.

Dr. Abdulaziz B. Alharby He is working as an associate professor in plant production and protection department, of agriculture college, Qassim University, Buraydah, KSA.