ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 10, Issue, 07, pp.9861-9864, July, 2019

RESEARCH ARTICLE

ASSESSMENT OF PUBLIC PRESCHOOL INDOOR AIR QUALITY IN PRESCHOOL AGE CHILDREN, JEDDAH CITY, 2018

***,[1]Bayan Hashim Al Sharif and [2]Sulafa Tarek Alqutub**

[1]Department of Community Medicine, Ministry of Health, Jeddah, Saudi Arabia
[2]Planning Department, Saudi Commission for Health Specialties, Jeddah, Saudi Arabia

ARTICLE INFO

Article History:
Received 27th April, 2019
Received in revised form
24th May, 2019
Accepted 20th June, 2019
Published online 31st July, 2019

Key words:

Indoor air quality, carbon dioxide, particulate matter, preschool.

ABSTRACT

Background and objective: Quarter of the world population estimated to be exposed air pollution, from these population children are considering to be at risk as they spent 90% of their time indoors and mostly in school. The school is an important place for child psychosocial development and mental health. School environment has a direct effect on both physical and mental health of student, many health issues are associated with indoor air pollution (IAP) and with poor ventilation of the building and humidity. In 2017 world health organization (WHO) report that respiratory infection like pneumonia attributed to IAP and outdoor air pollution (OIP) and second-hand smoking caused death of 570 000 children under 5 years, this study aims to assess IAQ in public preschool in Jeddah. **Methodology:** This is a cross sectional study conducted in Jeddah, the preschool was selected according to the geographical location of the ministry of education, four preschools were selected. We used the following devise to assess the IAQ: an air detector for Formaldehyde (HCHO), Volatile Organic Compound (VOC) and fine particulate dust matter measuring (PM2.5) and (PM10), a carbon dioxide (CO2) detector with temperature and humidity. **Result:** Most of IAQ measure fall within normal range of WHO guideline except for CO2, we recorded the highest reading in the preschool in the east region (1595.78± 393.900) ppm and lowest reading in the preschool in the north (1143.27± 356.559) ppm **Conclusion:** Inadequate ventilation for the classroom during lesson were the main finding, high number of students in small classroom, closing window and door during lesson were mainly the cause of the high CO2. Education for the preschool teacher in how to maintain good air quality inside classroom and how to maintain active air way exchange is recommended.

***Citation: Bayan Hashim Al Sharif and Sulafa Tarek Alqutub,* 2019.** "Assessment of public preschool indoor air quality in preschool age children, jeddah city, 2018", *Asian Journal of Science and Technology*, 10, (07), 9861-9864.

Copyright © 2019, Bayan Hashim Al Sharif and Sulafa Tarek Alqutub. *This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

INTRODUCTION

Keeping a health environment is one of the challenges in the world, people across the world start caring for the environment and its effect on health and disease development (1). As children spent 90% of their time indoors and mostly in school, school is considers as an important place for the development of the child psychosocial aspect and mental health, School environment have a direct effect on both physical and mental health of the student and teachers (Somersalo, 2002). The American Academy of Pediatrics (AAP) (1993) defines a healthful school environment as " *one that protects students and staff against immediate injury or disease and promotes prevention activities and attitudes against known risk factors that might lead to future disease or disability"* (Muller, 2010). In a safe and healthful school environment, identification of potential hazards have been made and actions have to take a place to reduce any potential for injury or illness (Muller, 2010). In 2016 WHO estimated that 25% to 33% of global burden of disease related to environmental risk factors. Focus on reducing environmental and social risk factors will lead to a reduction in the global burden of disease (WHO, 2016).

One of the most cost effective preventive method is the investment in school health program, WHO is using the health promoting school program as a strategy to prevent important health risks among youth control of school health environment can reduce the risk of many disease like respiratory illness, musculoskeletal pain and injury (WHO, 2010). The global morbidity and mortality related to respiratory diseases in children has been a major issue in health care systems in both developing and developed countries.[6]In 2000, WHO state that (IAP) was responsible for more than 1.5 million deaths and 2.7% of the global burden of disease (http://www.who.int/indoorair/publications/fuelforlife/) (7). In 2017 WHO report that respiratory infection like pneumonia attributed to IAP and outdoor air pollution (OIP) and second-hand smoking caused death of 570 000 children under 5 years (http://www. who.int/news-room/detail/06-03-2017-the-cost-of-a-polluted-environment-1-7-million-child-deaths-a-year-says-who). Air pollution (AP) is the contamination of the indoor or outdoor environment by any physical, biological or chemical agent that modifies the natural characteristics of the atmosphere (http://www.who.int/topics/air_pollution/en/). Frequently, IAP sources may build up to appreciable levels due to the slowness

of air exchange. It is estimated that a quarter of the world population is exposed to unhealthy concentrations of air pollutants and children are the ones most at risk of these (IAP) due to their respiratory organ systems immaturity (Mundackal, 2010). Schools are involved in some activities that have a range of hazards. These hazards and the risk associated must be managed to ensure the safety of the staff, students and visitors. One of these hazard is AP, it is consider one of the most serious environmental health problems most often the cause of it by human activities like transportation, construction industrial work, agriculture, mining and smelting (https://www.environmentalpollutioncen ters.org/air/). The most important IAP From the health point of view are particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOC) (Franklin, 2007) (Meininghaus *et al*., 2003). CO2 is a colorless, odorless, non-flammable gas (https://ohs online.com/articles/2016/04 /01/carbon-dioxide-detection-and-indoor-air-quality-control.as px) (14), it is a production of normal cell function and it is removed from the body through the lungs. It is also produced when fossil fuels are burned (https:// hsonline.com/articles /2016/04/01/carbon-dioxide-detection-and-indoor-air-quality-control.aspx). A review conducted in 2018 indicate CO_2 concentration is an indirect index of the contamination of IAQ (Azuma *et al*., 2018). It have many effects on the health, a study conducted in 2010 show that exposure of indoor CO_2 concentrations with dry cough and rhinitis were statically significant (Simoni *et al*., 2010).

PM is a mixture of solid particles and liquid droplets found in the air. Some particles are visible and can be seen with naked eye like dust, dirt, soot, or smoke. Others are so small they be detected by an electron microscope. These Particle pollutions includes PM_{10} which is inhalable particles Its diameters that are generally 10 micrometers and smaller and $PM_{2.5}$ which is fine inhalable particles, its diameters that are generally 2.5 micrometers and smaller. Some PM are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires. Most PM form in the atmosphere as a result of complex reactions of chemicals such as SO_2 and nitrogen oxides (NO), which are pollutants emitted from power plants, industries and automobiles (https://www.epa.g ov/pm-pollution/particulate-matter-pm-basics). In 2004 a Comparative quantification of health risks Global and Regional Burden of Disease Attributable to Selected Major Risk Factors have been conducted, it is estimated that approximately 3% of cardiopulmonary and 5% of lung cancer deaths are attributable to PM. In the European Region, this proportion is 1–3% and 2–5%, respectively, in various subregions (Ezzati *et al*., 2006). In 2010 a systematic analysis for the Global Burden of Disease have been conducted in 21 regions, this study estimates that ambient air pollution, as annual PM2.5, accounted for 3.1 million deaths and around 3.1% of global disability-adjusted life years (DALY) (Lim *et al*., 2012). According to the author Knowledge limited studies have been conducting regarding air quality in Saudi Arabia and this the first study to assess IAQ in preschool. The main objective of this study was to assess IAQ in public preschool in Jeddah city.

MATERIALS AND METHODS

A cross sectional study has been carried out between November to December 2018, By stratification, according to Ministry of Education (MOE) geographical mapping, there are four geographical area in Jeddah, (Central, East, South, and North).A total 51 preschool are distributed as follow: the central area includes 13 public preschool, the eastern area contains four preschool, the western area includes 13 preschool, and the north area contains 21 preschool.

Data collection tools

IAQ instruments: Ingress is an air quality detector for the following indicator: Formaldehyde (HCHO), Volatile Organic Compound (VOC) and fine particulate dust matter measuring (PM2.5 and PM10), and Az-5577 to detect CO_2, temperature and humidity.Wefollowed the guideline of WHO(20), Canada (21)and Australie(22)to interpretour result (Table 1)(23).

Data collection technique : After obtaining ethical approval from Saudi Board of Community Medicine Research Committee, Ministry of Health and Administrating Education, we visit the selected preschool to assess IAQ of the classroom using the instruments. Instruments placed during occupying hours approximately at the level of children's breathing zone at a height of about 0.6–1.5 meters above the floor, the selected place was not closer than 1 meter to a wall, a door, or an active heating system.

RESULT

We conducted the study among 4 kindergarten located in south, west, center area in Jeddah city. Majority of IAQ measure in the four preschool classroom environments were within stander level of WHO, except for the CO2 which was high in three out of four preschools with mean value of 1423.001± 369.086 (Table 1). The result sow there is a statistically significant difference (P >0.05) between the IAQ measure means between the four school (Table 2).

DISCUSSION

Comparison of IAQ between preschool: Between the four preschools, Classroom of the North preschool show a statically significant low concentrations levels of CO_2, $PM_{2.5}$, PM_{10} and VOCs, on the other hand classroom of Eastern preschool show highestlevels of CO_2, VOCs and humidity.

Carbon Dioxide (CO_2): The high concentration could be explained by possibly higher pollutant in this area (Azuma *et al*., 2018), high level of CO_2 could be due to inadequate ventilation (Rosbach *et al*., 2013). According to WHO guideline limited amount for CO2 is 1000 ppm[20], our study showed that three out of the four preschools have a concentration level above WHO stander levels. The average highest concentration was recorded in Eastern preschool (1595.78± 393.900) ppm and lowest recoded in North preschool (1143.27± 356.559) ppm, a study conducted in 2015 in Poland which the measurements were taken prior to the arrival of children and staff, as well as after all the classes had been occupied they noted that measurement of IAQ was low in the afternoon[25]. Other study in another countries reported a similar result of CO2 level that exceeded the recommended level like the one that conducted in 2014 in Malay (http://dx.doi.org/10.1016/j. proenv.2015.10.054), a study conducted in 2014in Portuguesa show same result (Araújo-Martins *et al*., 2014), this inadequate ventilation can be explained by the small size of the classroom, overcrowding

Table 1. Guidelines of IAQ mesurement

Indicator	WHO guideline	Canada	Australia
HCHO	.081 (100 µg/m3)	0.1ppm(123µg/m3) as1–h average	NA
VOC	300 (100 µg/m3)	NA	NA
PM2.5	NA	100µg/m3as1–h average	NA
PM10	NA	NA	90 µg/m3 as1–h average
CO2	1000 PPM	NA	NA
Temperature	NA	20.0–23.5°C in winter	NA
Humidity	NA	30–55% in winter	NA

Table 2. Mean of IAQ measurements

IAQ measure	Mean (± SD)
Formaldehyde	.02485(± .058729)
Volatile Organic Compound	.28145 (± 1.331696)
Particulate matter 2.5	.01429(± .005646)
Particulate matter 10	.02(± .007)
Carbon dioxide	1423.01 (± 369.086)
Temperature	23.86(± 2.049)
Humidity	41.03 (± 6.232)

Table 3. IAQ measure in classroom

	Studied preschool	Centre	East	South	North	P. Value
		Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd	
1.	Formaldehyde	.0163±.023	.0500±.098	.0116±.023	.0167±.026	0.00*
2.	VOC	.0720±.142	.888±2.356	.0188±.043	.0013±.001	0.00*
3.	PM 2.5	.0069±.001	.0200±.003	.0134±.004	.0150±.001	0.00*
4.	PM 10	.0069±.001	.0217±.004	.015±.005	.0186±.006	0.00*
5.	CO2	1291.0±122	1595.8±393.9	1529.25.23±3	1143.3±356.6	0.00*
6.	Temperature	.25.23±3.64	23.43±.817	23.46±1.56	23.65±.39	0.00*
7.	Humidity	36.19±4.87	46.70±4.74	37.21±4.69	43.57±1.955	0.00*

and the practice of closing doors and windows during session which prevent the active airway exchange, moreover the worm wither condition in Jeddah prevent frequent window opening.

Particulate matter ($PM_{2.5}$ and PM_{10}): The highest indoor concentrations of all PM ($PM_{2.5,}$ PM_{10}) were found in the Eastern preschool. Meanwhile, lowest concentration observed in the central region. This discrepancies between the four preschools was statically significant ($p = 0.00$). All reading of PM was below the recommended level of Canada and Australia. Many studies have been conducted regarding PM, almost all studies report PM level were exceeding the recommended level(28).This difference in the result may be due to the difference in the method of measuring PM, in which they measure it 24 hours while in our study it was measure once during session, another factor may be due to the different tools we used.Almost All measure of IAQ were within normal except for CO_2, the mean recorded of CO_2 inside classroomswere higher than the value which is recommended by the WHO. These results reflect the relative bad indoor air quality in the preschools of Jeddah due to the inadequate ventilation and the lack of environmental awareness.

Limitation: In our study time was limited, we have a limited time to conduct the study so we should highlight the fact that this study conducted during one season more research is recommended during other season, also limited tools were used during this study due to limited fund, more advance equipment's are required for future research.

Conclusion

Inadequate ventilation for the classroom during lesson were the main finding, high number of students in small classroom, closing window and door during lesson were mainly the cause of the high CO_2. Education for the preschool teacher in how to maintain good air quality inside classroom and how to maintain active air way exchange is recommended.

Acknowledgements: The authors would like to thank Dr.Reem Alnemari for lending the equipment to measure IAQ, ministry of education and staff of the preschools that participated in the study.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

1. Environment H. The Physical School Environment. In.
2. Somersalo, H. 2002. children ' s mental well-being.
3. Muller, G. 2010. School Health Services and Healthful School Environment. Sch Heal Serv Heal Sch Environ 02 [Internet]. Available from: highered.mheducation.com /sites/dl/free/0078028515/947552/Ch02.pdf.
4. WHO, 2016. Department of Public Health, Environmental and Social Determinants of Health. WHO [Internet]. [cited 2017 Oct 17]; Available from: http://www.who.int/ph e/a bout_us/en/.
5. WHO, 2010. School health and youth health promotion: facts. WHO [Internet]. [cited 2017 Oct 15]; Available from: http://www.who.int/school_youth_health/facts/en/.
6. Mulholland, K. 2003. Global burden of acute respiratory infections in children: Implications for interventions. Pediatr Pulmonol [Internet]. [cited 2018 Mar 7];36(6):469–74. Available from: http://www.ncbi.nlm.nih.gov/pubmed/ 14618637.
7. National Burden of Disease Estimates [Internet]. 2007 [cited 2018 Dec 5]. Available from: http://www.who.int/indoorair /publications/fuelforlife/
8. World Health Organization (WHO). The cost of a polluted environment: 1.7 million child deaths a year, says WHO [Internet]. 2017 [cited 2018 Dec 5]. Available from: http://www.who.int/news-room/detail/06-03-2017-the-cost-of-a-polluted-environment-1-7-million-child-deaths-a-year-

says-who
9. WHO, 2017. Air pollution. WHO [Internet] [cited 2017 Oct 17]; Available from: http://www.who.int/topics/air_poll ution/en/.
10. Mundackal, AJ. 2010. A survey of respirtory health status of 10 year old children in Vaal Triangle Priority Area.
11. What Is Air Pollution | Environmental Pollution Centers [Internet]. [cited 2017 Oct 17]. Available from: https://www.environmentalpollutioncenters.org/air/
12. Franklin, PJ. 2007. Indoor air quality and respiratory health of children. *Paediatr Respir Rev.,* [Internet]. [cited 2018 Mar 7];8(4):281–6. Available from: http://www.ncbi.nlm.nih.go v/pubmed/18005895.
13. Meininghaus, R., Kouniali, A., Mandin, C. and Cicolella, A. 2003. Risk assessment of sensory irritants in indoor air--a case study in a French school. Environ Int [Internet]. Jan [cited 2018 Mar 7];28(7):553–7. Available from: http://ww w.ncbi.nlm.nih.gov/pubmed/12504150.
14. Carbon Dioxide Detection and Indoor Air Quality Control - - Occupational Health & Safety [Internet]. [cited 2019 Jul 7]. Available from: https://ohsonline.com/articles/201 6/04/01/carbon-dioxide-detection-and-indoor-air-quality-control.aspx.
15. Azuma, K., Kagi, N., Yanagi, U. and Osawa, H. 2018. Effects of low-level inhalation exposure to carbon dioxide in indoor environments: A short review on human health and psychomotor performance. Environ Int [Internet]. Dec 1 [cited 2019 Jul 7];121:51–6. Available from: https://w ww.sciencedirect.com/science/article/pii/S0160412018312 807?via%3Dihub#bb0255.
16. Simoni, M., Annesi-Maesano, I., Sigsgaard, T., Norback, D., Wieslander, G., Nystad, W., *et al*., 2010. School air quality related to dry cough, rhinitis and nasal patency in children. Eur Respir J [Internet]. Apr 1 [cited 2019 Jul 7];35(4):742–9. Available from: http://www.ncbi.nlm.nih .gov/pubme d/20075060.
17. US EPA O. Particulate Matter (PM) Basics. [cited 2017 Dec 10]; Available from: https://www.epa.gov/pm-pollution/par ticulate-matter-pm-basics
18. Ezzati, M., Hoorn, S., Vander, Lopez, AD., Danaei, G., Rodgers, A., Mathers, CD., *et al*., 2006. Comparative Quantification of Mortality and Burden of Disease Attributable to Selected Risk Factors [Internet]. Global Burden of Disease and Risk Factors. The International Bank for Reconstruction and Development / The World Bank; [cited 2018 Dec 5]. Available from: http://www.n bi.nlm.nih.gov/pubmed/21250375.
19. Lim, SS., Vos, T., Flaxman, AD., Danaei, G., Shibuya, K., Adair-Rohani, H., *et al*. 2010. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-a systematic analysis for the Global Burden of Disease Study 2010. Lancet (London, England) [Internet]. 2012 Dec 15 [cited 2018 Dec 5];380(9859):2224–60. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23245609.
20. WHO, 2006. Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide [Internet]. [cited 2019 Jul 7]. Available from: https://apps.who.int/iris/bits tream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02 _eng.pdf;jsessionid=CF5BFE9B4141015276959B54765B B894?sequence=1.
21. Government of Canada HCPAC and CB, Gouvernement du Canada SCD générale des affaires publiques, de la consultation et des communications. Welcome to the Health Canada Web site | Bienvenue au site Web de Santé Canada. [cited 2019 Jul 7]; Available from: http://www.hc-sc.gc.ca/
22. Home | NHMRC [Internet]. [cited 2019 Jul 7]. Available from: https://www.nhmrc.gov.au/
23. Abdul-Wahab, SA., Chin Fah En, S., Elkamel, A., Ahmadi, L. and Yetilmezsoy, K. 2015. A review of standards and guidelines set by international bodies for the parameters of indoor air quality. Atmos Pollut Res [Internet]. 6(5):751–67. Available from: https://linkinghub.elsevier.com/retrie ve/pii/S1309104215301689.
24. Rosbach, JTM., Vonk, M., Duijm, F., van Ginkel, JT., Gehring, U. and Brunekreef, B. 2013. A ventilation intervention study in classrooms to improve indoor air quality: the FRESH study. Environ Health [Internet]. Dec 17 [cited 2019 Jul 7];12:110. Available from: http://www.n cbi.nlm.nih.gov/pubmed/24345039.
25. Gładyszewska-Fiedoruk, K. 2013. Correlations of air humidity and carbon dioxide concentration in the kindergarten. Energy Build [Internet]. [cited 2019 Jul 4];62:45–50. Available from: https://www.sciencedirect.com/science/ article/pii/S0378778813001461?via%3Dihub.
26. Chua, P., Juliana, J., Titi, R. and Nor, M. 2015. Preschool s ' indoor air quality and respiratory health symptoms among preschoolers in Selangor. Procedia Environ Sci [Internet]. 30 (November):303–8. Available from: http://dx.doi.org/10 1016/j.proenv.2015.10.054.
27. Araújo-Martins, J., Carreiro Martins, P., Viegas, J., Aelenei, D., Cano, MM., Teixeira, JP., *et al*., 2014. Environment and Health in Children Day Care Centres (ENVIRH) – Study rationale and protocol. Rev Port Pneumol (English Ed [Internet]. [cited 2019 Jun 30];20(6):311–23. Available from: https://linkinghub.elsevier.com/retrieve/pii/S21735 11514001092.
28. Mainka, A. and Zajusz-Zubek, E. 2015. Indoor Air Quality in Urban and Rural Preschools in Upper Silesia, Poland: Particulate Matter and Carbon Dioxide. Int J Environ Res Public Health [Internet]. [cited 2019 Jul 6];12(7):7697–711. Available from: http://www.ncbi.nlm.nih.gov/pubm ed/2618 4249.
29. Rovelli, S., Cattaneo, A., Nuzzi, C., Spinazzè, A., Piazza, S., Carrer, P., *et al*., 2014. Airborne Particulate Matter in School Classrooms of Northern Italy. *Int J Environ Res Public Health.,* [Internet]. [cited 2019 Jul 6];11(2):1398–421. Available from: http://www.ncbi.nlm.nih.gov/pu bme d/24473114.

****