Open Access **Baghdad Science Journal** **P-ISSN: 2078-8665**
2021, Vol. 18 No.1 (Suppl. March) **E-ISSN: 2411-7986**

DOI: http://dx.doi.org/10.21123/bsj.2021.18.1(Suppl.).0687

Measurement of some Air Pollutantsin Printing Units and Copy Centers Within Baghdad City

***Adel H. Talib*[1*]** ***Zainab N. Abdulateef*[2]** ***Zainab A. Ali*[1]**

[1] Biology Department, College of Science for Women, Baghdad University, Baghdad, Iraq.
[2] Ministry of Education, Baghdad, Iraq.
[*]Correspondence:adelht_bio@csw.uobaghdad.edu.iq[*],zainab.anwar@csw.uobaghdad.edu.iq, zainab2bio@gmail.com.
[*]ORCID ID: https://orcid.org/0000-0002-7749-012X[*], https://orcid.org/0000-0002-0855-0862, https://orcid.org/0000-0001-9047-0986

Received 8/7/2019, Accepted4/5/2020, Published 30/3/2021

Abstract:

Emissions of particulate matter from nanopapers as well as inks and organic solvents during the printing operationand copying machines constitute a threat to human health, especially with long time exposure in closed working environments. The present study was conducted in some printing houses and copying centers of Baghdad city during February and April.The studyproved the occurrence of an air pollution problem concerning lead and zinc contents in all the study sites. The levels of Pb, Zn and Cu were collected by low volume sampler from the air of the study sites then filter papers digested and determined the heavy metals by flame atomic spectrophotometer. Particulate matter was measured by Aerocet, Microtector meter device was used to measure nitrogen dioxide, sulphur dioxide, carbon monoxide and volatile organic compounds . The highest concentrations of lead and zinc were recorded in the printing houses air (2.75µg/m^3) and (51.95µg/m^3) respectively. In contrast,copper concentration in the copying offices air recorded a significantly higher value (0.65µg/m^3) ($P<0.05$) as compared to that in printing houses. Fine particulate matter($PM_{2.5}$)(particles diameter < 2.5 µm) hasrecorded the highest concentration (44.50µg/m^3) in printing houses, followed by the highest concentrations of inhalable coarse particulate matter (PM_{10}) (particles with diameter of 2.5 to 10 µm) and total suspended particulates (TSP)(the total of solid particles) (477.66 and 667.00µg/m^3) respectively in printing houses. The results obviously showed the highest concentrations of carbon monoxide (CO) (6.13 ppm) and volatile organic compounds (VOCs) (21.88 ppm) in printing houses, while nitrogen dioxide (NO_2) recorded its highest concentration (1.44 ppm) in copy centers. Lead, zinc, copper, $PM_{2.5,}$ PM_{10} and TSP concentrations exceeded the permissble levels in all study sites conversely with the levels of carbon monoxide , nitrogen dioxide, sulphur dioxide(SO_2) and volatile organic compounds that were within permissible air quality standards.

Keywords: Heavy metals,Indoor air quality, Photocopier, particulate matter, Volatile organic compounds.

Introduction:

The increasing demand for printers and copying devices without knowing their health risks of volatilization of inks and solvents caused a lot of health and respiratory risks to workers and ordinary people as well as a potential source of indoor air pollution. Several studies have indicated prevalence of many of respiratory symptoms pulmonary restrictive sings and oxidative stress in photocopying and printing workers (1,2). Printers and copying devices during their operation emit various types of pollutants into the indoor air environment including nanoparticulate matter released into the air, together with other semi-volatile organic nanoparticles, and newly formed gaseous co-pollutants such as volatile organic compounds and other toxic gases nitrogen dioxide, sulphur dioxide, carbon monoxide), lead, nickel, benzene, arsenic, ammonia, paper minutes and inks particle (3-5). The basic composition of the particulate matter consists of iron, lead, zinc, carbon and many other metals produced by heat-generated during printing process from inks and toners as well as paper particles(6,7). Synthetic resins, pigments, and additives make up the elements of toners, toner layer contains solid surface or granular surface, toners structures differences according to the

printing device such as Konica Minolta, Canon, OKI, Hewlett–Packard, Lexmark, Epson, Dell, Ricoh, Brother, and Xerox(8). The volumes of the inks particles have gradually decreased to improve print quality. Because of the small size of these molecules, they can penetrate into the respiratory system and stabilize withinlungs deeply during operation and maintenance. Epidemiological studies reported the prevalence of *chronic* cough, wheezing, nasal blockage, excessive sputum production, breathing difficulties, and shortness of breath, in copier operators(9). Printing inks and toner containing the heavy metals form part of its components. US environmental protection agency listed many of heavy metals that content in offset printing inks such as barium, cadmium, copper, lead, mercury, nickel, zinc, arsenic, chromium, selenium and silver(10). Most heavy metals are dangerous because they tend to bioaccumulatein body human (11).

Particulate matter is a key indicator of air pollution brought into the air by a variety of natural and human activities. The size of particles has been directly linked to their potential for causing health problems. Many health effects like eye irritation, dry throat, runny nose, sneezing, cough, tiredness, irritability, difficulty concentrating, headache, dizziness, and skin irritation associated with these particulates reported (12).Particulates with diameter 10 μm emitted from printing inks pose health risks and can lead to lung inflammation and lung cancer due to the contamination of these molecules, which can have a toxic effect within cells and be mutagenic (13).The exposure to particulate matter and volatile organic compounds emitted from copying devices may cause lung problems, inflammation, DNA damage and genotoxicity (14).High levels of nanoparticles (PM0.1) emitted from photocopying toners contain organic and elemental carbon, metals including iron, zinc, titanium, chromium, nickel and manganese (15).Ultra fine particles are released during printing activities or arise from ozone reaction with volatile organic compounds emitted from printers .Ultra fine particles are influenced by indoor ventilation conditions as well as printer parameters such as printer type, age of printers and number of pages printed. Printers release a large amount of volatile organic compounds VOCs during printing activities, the concentration levels of VOCs styrene, benzene, chlorobenzene, toluene, ethylbenzenes, styrene and xylenes increased during printing activities especially during peak hours of printing and the source of styrene was toner dust in printer cartridges (16,17).

Industrial processes are the largest contributor to the emissions of human volatile organic compounds and their global emissions are estimated at about 27 g/year resulting from the use of industrial solvents in dyes, inks, etc. Symptoms of direct exposure to VOCs nose and throat irritation, headache, skin allergies, nausea, dizziness and fatigue (18,19). The US Environmental Protection Agency has classified VOCs as hazardous air pollutants, for example, benzene. Many studies have revealed that exposure to benzene or products containing benzene cause different types of leukemia (20).

Here, current study sought to assess air quality of the printing houses and copy centers environment and detectthe of presence some concentrations of heavy metals (Lead, zinc, and copper) and particulates matter emitted from working environment.

Materials and Methods:

Sampling Sites

Work sites included (two printing houses and seven copy centers) on both sides of Karkh and Rusafa within Baghdad city/Iraq. Al-Nahrain press for printing and publishing Southwest of Baghdad (33°18'36"N, 44°21'39"E). The University Press and Publishing House located inside the University of Baghdad, Jadriya (33°16'25"N,44°22'56"E), and seven copy centers of Bab AlMu'adham(33°21'07"N,44°23'34"E) . In order to compare the quantity of pollutants in presses and copy centers offices, the samples were collected through daily working hours estimated from 6 to 9 hours per day .

The Study of work environment pollutants

Three metals: Lead (Pb), Zinc (Zn) and Copper (Cu), in addition to particulate matter ($PM_{2.5}$, PM_{10}) Total Suspended Particulates (TSP) and some air pollutants (CO, NO_2, SO_2, VOCS) were collected and covered the study sites.

Collecting some of heavy metals samples

A device known as (sniffer) Low volume air sampler was used to estimate the level of Lead, Zinc, Copper in the air presses and copy centers after the collection. The samples were digested according to standard methods (21) and heavy metals Pb, Zn, and Cu were determined by Flame Atomic Spectrophotometer according to Standard methods (22).

Particulate Matters in the air of the working environment

The total suspended particulates and particulate matter of the sizes ($PM_{2.5,}$ PM_{10}, TSP)in the airwere measured during February and April by Aerocet 531 device close to the breathing level of the workers in their work place in (milligrams) per cubic meter.

Air polluted gases and VOCs

Air polluted gases (NO_2, SO_2,CO) and VOCs were measured in the working environment close to the breathing level of workers by Microtector meter device II G460 of the unit (ppm) to see how it affects the respiratory health of the workers.

Statistical Analysis

The Statistical Analysis System ANOVA (23) was used to show the effect of a different group in study parameters. The least significant difference–LSD test was used to significantly compare between the means in this study.

Results and Discussion

Heavy Metals in the working environmentair

In order to improve indoor air quality, it is necessary to study the sources of emissions from chemical compounds. Descriptive statistics of heavy metal concentrations in the air of study sites are summarized in (Table 1).The highest value of lead (2.75±0.06µg/m^3) was observed in the air of Printing housesenvironment compared to the least mean value of lead (2.44±0.09µg/m^3) in copying centers environment(Table.1).There were no significant differences between the study sites. The results of the current study exceeded the globalthe permissible limits (24).This means that there is lead contamination increasing with the increase in working time with using printing inks. A previous study indicated the high percentage of lead in air pressesin the printing housesair near the furnace (7) .

Inks used in printing and copying contain additives and solvents that are the main reason for the increased concentration of lead in the air of the working environment. Heavy metals lead, Cadmium, hexavalent chromium, and mercury were found in printing inks which are toxic heavy metals that are hazardous to human health (25).

Zinc recorded the highest value (51.95±6.52 µg/m^3) in the air of the printing houses environment compared to the least value in the air of copying centers (42.21±3.69µg/m^3) (Table1). Zinc concentrations in the study sites exceeded the global determinants at high rates. The high value of this component is due to its emission from the parts of the machines due to friction with each other such as the bonding tools as well as the components of inks of heavy metals because inks contain heavy metals such as lead, cadmium, zinc, copper, barium, selenium, chromium, arsenic, nickel, which are used as inks in offset machines with pigments blue, red, yellow, green, and the basic black (10).

Table 1.Descriptive statistics of HM in study sites.

Study Sites	Mean of HM Concentrations in the air of study sites (µg/m^3) ± SE		
	Pb	Zn	Cu
Printing houses	2.75±0.06	51.95±6.52	0.24±0.02
Copying centers	2.44±0.09	42.21±3.69	0.65±0.05
LSD value	0.702NS	8.973 *	0.219 *

*Significant differences (P<0.05) NS: Non Significant differences.
P: probability HM: Heavy Metals.

The highest value observed in the mean of the copper was in the air of copying centersenvironment (0.65±0.05 µg/m^3) with significant increasing at (P<0.05) compared to the mean of copper in the air of printing houses environment(0.24±0.02µg/m^3).Copper concentrations exceeded the permissible global limits. This increase is due to the friction of the parts of the machines usually manufactured from Copper as well as heating the printing inks during the printing process which contributes to their emission to the working environment (Table.1).

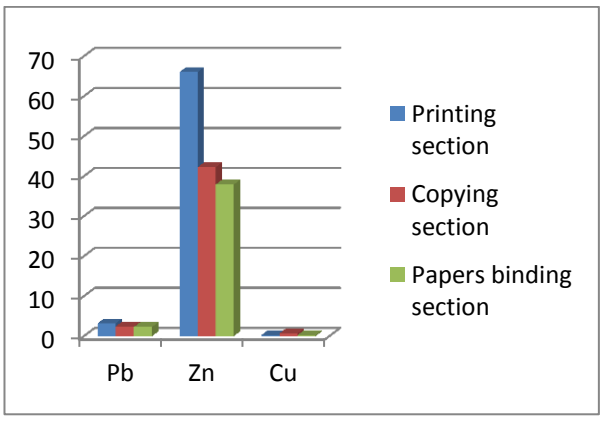

Figure 1. HM concentrations in section sites (µg/m^3)

Figure 1 shows the percentage of heavy metals pollution in papers binding section was the least compared to printing and copying sections,

The machines were far from it, which made it record lower percentages of heavy metals, and this indicates that it is the closer the work to the printing and copying devicesthe more air pollution by heavy metals .

Particulate Matter in the air of working environment

The results in the (Table2) show data mean of particulate matter and total suspended particulate in all study sites. It seems clear that the highest values of $PM_{2.5}$ and PM_{10} were found in the air of printing environment (44.50±1.08µg/m^3) and(477.66±32.78µg/m^3) respectively compared to the least values of the air of $PM_{2.5}$and PM_{10} in thecopying centers environment (31.00±11.98µg/m^3) (225.85±39.39µg/m^3).TSP also recorded the highest value noticed in the air of printing environment (667.00±16.42 µg/m^3) compared to the leastvalue in the air of copying centersenvironment (303.28±35.15 µg/m^3).When comparing these values of $PM_{2.5}$, PM_{10} with global determinants, we find it exceed thepermissible limits (25 µg/m^3 and 50µg/m^3) respectively in all of the study sites. Higher particulate matters rates increase in copying centers and coincide with the increased number of copies per day and poor ventilation (26).

Table 2. Measurement of PM & TSP in the air of study sites (µg/m^3)

Study Sites	Mean of PM and TSP Concentrations in the air of study sites ± SE		
	$PM_{2.5}$ (µg/m^3)	**PM_{10} (µg/m^3)**	**TSP (µg/m^3)**
Printing houses	44.50±1.08	477.66±32.78	667.00±16.42
Copying centers	31.00±11.98	225.85±39.39	303.28±35.15
LSD value	17.923 NS	106.48 **	156.37**

** (P<0.01)Highly significant differences NS : (Non-Significant)

The statistical test referred to a highly significant differences in the mean of PM_{10} values between the air of printing houses and the air of copying centers environment pollutants according to the value of LSD (106.48,P<0.01) Moreover, it was noticed that highly significant differences were noticed in the mean of TSP concentrations between the air of printing and the air of copying centers environment pollutants according to the value of LSD (156.37, P<0.01) (Table.2). These differences are due to the poor ventilation and the lack of air fans in the printing environment especially that printing presses have a large unhealthy construction areas compared to the copying centers which are usually small as well as printing houses contain many machines ranging from offset machines used for printing, cutting machines, thermal machines and many machines of different sizes vary according to the nature of its work. Particulates are also emitted from shearing machines in the presses to the working environment and because of the workers proximity tothese machines and small particulates size, they enter through the respiratory tract of workers and cause health problems for them (27).Fine particulate matter shows less density after one hour of the printing operations and the resting time (28) .

As forcomparing the concentration values of particulate matters in printing houses and copying centers during February and April, the readingsrecorded a noticeable increase in the percentage of concentrations during April compared to February in all of study sites, printing houses particulate matters recorded obvious differences (Fig.2), where $PM_{2.5}$ reached (44.50 µg/m^3) during April compared to February(26.7 µg/m^3), While PM_{10} reached (477.66µg/m^3) in April compared to February(157.1 µg/m^3) Whereas,TSP reached (667.00 µg/m^3) in April compared to February (201.265 µg/m^3).

Copying centers also recorded a remarkable rise in $PM_{2.5}$ in April reached (31.00 µg/m^3) compared with February (18.42 µg/m^3), whereasPM_{10} reached (225.85 µg/m^3) in April compared with February (129.57 µg/m^3), finally TSP recorded (303.28 µg/m^3) in April compared withFebruary (197.28 µg/m^3) (Fig.3).

The difference in the concentrations of particulate matter is due to the increase in air temperature and the increased demand for publications during April compared to February, as well as heating the printing inks in machines for the purpose of fixing the pigment particles on paper that contributed to raising the temperature of the work sites.

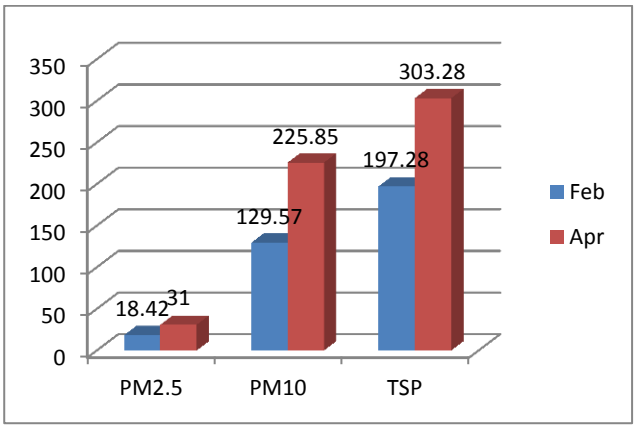

Figure 2. PM and TSP in printing houses during February and April (µg/m^3)

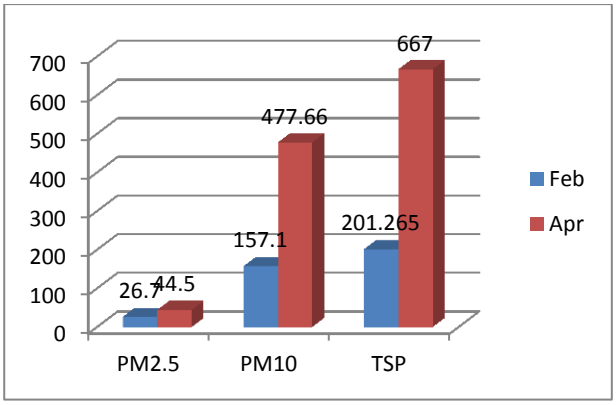

Figure 3. PM and TSP in Copying centers during February and April (µg/m^3)

Contaminated Gases and VOCs in the air of working environment

There are many global studies indicating the existence of printing and copying centers machinery emissions which is a complex mixture of molecules,and volatile organic compounds.The current study indicates the highest value of CO concentration reached (6.13 ppm) in the air of the printing environment (Table3) with significant differences (P<0.05) compared to copying centers which indicated that no air pollution with CO. Nitrogen dioxide and sulfur dioxide is considered as a major air pollutant emitted from various industrial sources (29) .The highest value of NO_2 reached (1.23 ppm) in the air of printing environment compared to the least value (1.44 ppm) recordedin copying centers environment which means there wereno significant differences among thestudy sites.On the other hand,SO_2did notrecord any concentration in both environments of printing and Copying centers.This means that there is no pollution in these sites with SO_2 .The results of gases concentrations did not exceed the permissible limits. VOCs recorded thehighest value (21.88 ppm) in the air of printing environment compared to the environment of copying centers (2.14 ppm) (Table.3). This study recorded significant differences (4.731) (p<0.05) between the study sites.This may be due to composition of toners and inks used in office equipmentfor example, printing houses inks are liquid, while the copying centers offices use powder dry ink, the toner cartridge as well as the size of work place, size of papers, size of printers,and number and type ofmachines. Emissions from printers and copiers also depend on the operation modes and thematerialsused(30).

Table 3. Mean of gases concentrations in study sites (ppm)

Study sites	Mean of gases concentrations			
	CO (ppm)	NO2 (ppm)	SO2 (ppm)	VOCs (ppm)
Printing houses	6.13	1.23	N.d.	21.88
Copying centers	N.d.	1.44	N.d.	2.14
LSD value	1.863*	0.368 NS	N.d.	4.731*

N.d. : Non detected NS: Non significant differences.*Significant differences (P<0.05)

VOCs measurements did not exceed global permissible limits. Office machines release volatile organic compounds from heating up the drum and toner up to 160 °C for compress toner on paper during peak hours of printing process. Printing inks are diluted by organic solvents emitted to the atmosphere during the printing process and are generated by heating and volatiles from digital printing ink, digital printing inks and flexographic which represent potential sources for volatile organic compounds. It is necessary to study emissions of chemical compounds used in the construction of office materials, furniture and office equipment, especially in low-ventilated closed environments (31-32).

Conclusions:

The current study isconducted to assess the air quality of the working environment in printing houses and copying offices to improve the safety of workers . Although the working environment varies between the printing houses and the copying offices in terms of the quality of the printers used, the principle of their work, their size and the printing method used, age of printers, types of ventilation, number of copies makeon an average work day as well as the size of the printing houses places compared to the size of copying offices.However,the results indicate

thatconcentrations of heavy metals (Pb, Zn, and Cu) in the air of all the study sites exceed the permissible global limits. Concentrations of particulate matters ($PM_{2.5}$, $PM_{10,}$ and TSP) also exceed the permissible global values in printing presses and copy centers which means contamination of heavy metals and particulate matter in the air of the working environment in printing houses and copy centers.The concentration of gases, by contrast,isvery little and doesnot exceed the permissible limits at all of study sites.

In accordance with these conclusions, the study recommends the following:

- It is necessary to use inks that don't contain hydrocarbons or low aromatics and that old machinesshould be replacedwith modern digital machines.
- Containers of inks should be cleaned in open areas and wiped with a cloth dampened with water. Inks should not be released to soil or water to prevent pollution of groundwater and soil .
- Ventilation in the workplace should be improved and adequate ventilation to air should be provided to get rid of odors from the inks and chemical vaporization
- Workers in printing houses and copying offices, especially thoseexposed for long periods of time, should be educated on how to deal with the equipment, toners in addition toprovidingthe necessary personal protective equipment.

Acknowledgment:

We thank all employees in the offices of copy centers of the Bab Al Mu'adham especially Mr. Fares Al-Musawi, Al-Nahrain press for printing and publishing and the University Press and Publishing House at the University of Baghdad for their cooperation in measuring the pollutants of the work environment, I would also like to extend my sincere thanks to the Occupational Health and Safety Center, the Environmental Research Center/ University of Technology, the Department of Environment and Water at the Ministry of Science and Technology for their cooperation in measurement the air pollutants, and the Poison Center staff at Ghazi Hariri Hospital for their cooperation in examination of samples.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Reference:

1. Karimi A, Eslamizad S, Mostafaee M, Momeni Z. Restrictive Pattern of Pulmonary Symptoms among Photocopy and Printing Workers: A Retrospective Cohort Study. J. Res. Health. Sci. 2016; 16(2):81-84 .
2. Awodele O, Akindele AJ, Adebowale GO, Adeyemi OO. Polycyclic Aromatic Hydrocarbon, Hematological and Oxidative Stress Levels in Commercial Photocopier Operators in Lagos, Nigeria. Ghana. Med.J . 2015; 49(1):37-43.
3. Pirela SV, Martin J, Bello D, Demokritou P. Nanoparticle exposures from nano-enabled toner-based printing equipment and human health: state of science and future research needs. Crit. Rev. Toxicol. 2017; 47(8): 683-709 .
4. Morawska L, He C, Johnson G, Jayaratne R, Salthammer T, Wang H, et al. . An investigation into the characteristics and formation mechanisms of particles originating from the operation of laser printers. Environ. Sci. Technol. 2009 ; 43(4): 1015–1022.
5. Elango N, Kasi V, Vembhu B, Poornima J. Chronic exposure to emissions from photocopiers in copy shops causes oxidative stress and systematic inflammation among photocopier operators in India. Environ. Health. 2013; 12:78.Available from: https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-12-78 DOI: 10.1186/1476-069X-12-78 .
6. Pirela S, Molina R, Watson C, Cohen JM, Bello D, Demokritou P. et al. Effects of copy center particles on the lungs: A toxicological characterization using a *Balb/c* mice model. Inhal.Toxicol. 2013; 25(9): 498–508.
7. Hassan BK, Naoum K F, Abdul Razzaq S. The effect of inorganic lead on the proportion of corporphyrin in the urine of workers who are exposed to lead in a printing house. AL-Taqani. J. 2007; 20 (1): 76-83.
8- Łasińska A. Assessment of the Possibility of Identification of Black Toners on Printouts in Lexmark Printers Using SEM Method.J. Microsc. Ultrastruct. 2018; 6(3): 145–159.
9- Kitamura H, Ogami A, Myojo T, Oyabu T, Ikegami K, Hasegawa M, et al. Health Effects of Toner Exposure Among Japanese Toner-Handling Workers: A 10-Year Prospective Cohort Study.J. UOEH. 2019; 41(1):1-14.
10. Environmental Protection Agency. Innovative Clean Technologies Case Study Second Year Project Report.Reducing Heavy Metals Content in Offset Printing Inks by Roger Telschow. Silver spring, USA. 1994; p. 117-125.
11. Jarup L. Hazards of heavy metal contamination. Br. Med. Bull. 2003; 68(1): 167-182.

12. Nezis I, Biskos G, Eleftheriadis K, Kalantzi O. Particulate matter and health effects in offices - A review.Build. Environ. 2019; 156(1) :62-73.
13. Getzlaff M, Leifels M, Weber P, Kokcam‐Demir Ü, Janiak Ch. Nanoparticles in toner material. SN. Appl. Sci. 2019; 1(5): 475-489.Avilable from: https://DOI.org/10.1007/s42452-019-0501-9
14. Kasi V, Elango N, Ananth S, Vembhu B. Occupational exposure to photocopiers and their toners cause genotoxicity. Hum. Exp. Toxicol. 2018; 37(2):205-217 .
15. Martin J, Bello D, Bunker K, Shafer M, Christiani D, Woskie S, et al. Occupational exposure to nanoparticles at commercial photocopy centers. J. Hazard. Mater. 2015; 298(1):351-360.
16. Kagi N, Fujii S, Horiba Y, Namiki N, Ohtani Y, Emi H, et al. Indoor air quality for chemical and ultrafine particle contaminants from printers . Build. Environ. 2007; 42(5): 1949-1954 .
17. Betha R, Selvam V, Blake D, Balasubramanian R. Emission characteristics of ultrafine particles and volatile organic compounds in a commercial printing center. J. Air. Waste.Manag. Assoc.2011; 61(11) (1093-1101) .
18. International Agency for Research on Cancer. Agents Classified by the IARC Monographs, Volumes1-108. 2013: Retrieved from http://monographs.iarc.fr/ENG/Classification/ Classifications Alpha Order .pdf.
19.U.S.Environmental Protection Agency. Volatile Organic Compounds (VOCs), United States Environmental Protection Agency. Retrieved on 30 July 2014, Available from :
http://ww w.epa.gov/iaq/voc2.html.
20. Kane EV, Newton R. Benzene and the risk of non-Hodgkin lymphoma: a review and meta-analysis of the literture. Cancer Epidemiol. 2010; 34(1):7-12 .
21.International Programme on Chemical Safety. Inorganic lead. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 165. 1995. Available from :http://www.inchem.org/documents/ehc/ehc/ehc165.htm).
22. HaswellSJ.Atomic Absorption spectrometry .Theory, Design and Application. 5th ed. The University of Hull: Elsevier; c1991. p.420-422.
23. Statistical Analysis System. User's Guide. Statistical version 9.1th (ed). SAS.Inst. Inc. Cary. NC, USA; 2012 . Chapter 17,The ANOVA Procedure; p.422-480 .
24.World Health Organization. WHO Expert Consultation: Available evidence for the future update of the WHO Global Air Quality Guidelines (AQGS) .Meeting report, Bonn, Germany. 29 September_1 October 2015 . Available from :
http://www.euro.who.int/__data/assets/pdf_file/0013/301720/Evidence-future-update-AQGs-mtg-report-Bonn-sept-oct-15.pdf
25. European Printing Ink Association. Environmental impact of printing inks .Information note. 2013 Mar ; p 12. Available from:
http://www.eupia.Org/uploads/tx_edm/20130305_EuPIA_Environment_Impact_of_ Printing_Inks.pdf
26.Martin J, Demokritou P, Woskie S, Bello D. Indoor Air Quality in Photocopy Centers, Nanoparticle Exposures at Photocopy Workstations, and the Need for Exposure Controls.Ann.Work. Expo. Health. 2017; 61(1):110-122.
27. Abdulateef ZN. Effect of some air pollutants emitted from printing units and copy centers environment on workers' health in Baghdad City-Iraq. MSc thesis: University of Baghdad ; 2016.
28.Mortaji N, Olya ME, Ataeefard M. Detection, Characterisation and Determination of Indoor Organic air Pollutants and Fine Particles Produced by Laser Printers. Orient. J. Chem. 2018; 34(4) : 1968-1977.
29. Jasim IM, Al-kubaisi AA, Al- Obaidy AM. Test the efficiency of some plants in the tolerant of air pollution within the city of Baghdad. Iraq. Baghdad. Sci. J. 2018; 15(1): 9-15 .
30. Kowalska J, Szewczyńska M, Pośniak M. Measurements of chlorinated volatile organic compounds emitted from office printers and photocopiers. Environ. Sci. Pollut. Res. Int. 2015; 22(7): 5241-5252.
31. Han KH, Zhang JS, Wargocki P, Knudsen HN. Model-based approach to account for the variation of primary VOC emissions over time in the identification of indoor VOC sources. Build. Environ. 2012; 57: 403–416. Available from: https://doi.org/10.1016/j.buildenv.2012.06.011
32. Król S, Zabiegała B, Namieśnik J. Monitoring and analytics of semi volatile organic compounds (SVOCs) in indoor air. Anal .Bioanal. Chem. 2011; 400(6): 1751–1769.

قياس بعض ملوثات الهواء في المطابع ومكاتب الاستنساخ ضمن مدينة بغداد

عادل حسين طالب [1] زينب نصر عبد اللطيف [2] زينب أنورعلي[1]

[1] قسم علوم الحياة، كلية العلوم للبنات، جامعة بغداد، بغداد، العراق .
[2] وزارة التربية، بغداد، العراق .

الخلاصة:

إن انبعاث المواد الدقائقية من الأوراق المتناهية الصغر فضلا عن الأحبار والمذيبات العضوية خلال عملية تشغيل ماكينات الطباعة والاستنساخ تشكل خطرا على صحة الإنسان بالأخص بعد التعرض طويل الأمد في بيئات العمل المغلقة . أجريت الدراسة الحالية في بعض دور الطباعة ومراكز الاستنساخ في مدينة بغداد خلال شهري شباط ونيسان، وأثبتت الدراسة حدوث مشكلة تلوث الهواء فيما يتعلق بمحتويات الرصاص والزنك في جميع مواقع الدراسة .تم تحديد تركيز الرصاص والزنك والنحاس من خلال جمع العينات بوساطة جهاز جمع عينات الهواء وبعدها تم ترشيح العينات وهضمها وتحديد نسبة العناصر الثقيلة بوساطة جهاز المطياف الذري اللهبي، أما المواد الدقائقية تم قياسها بوساطة جهاز قياس الدقائق العالقة في الهواء ، واستعمل جهاز قياس الغازات الملوثة للهواء لقياس غاز ثنائي أكسيد لنتروجين وثنائي أكسيد الكبريت وأول أكسيد الكربون والمركبات العضوية المتطايرة . سجل أعلى تركيز للرصاص والزنك في هواء المطابع (2.75 مايكرو غرام/م^3) و (51.95 مايكرو غرام /م^3) على التوالي . بالمقابل سجل أعلى قيمة معنوية نحاس في هواء مكاتب الاستنساخ (0.65 مايكرو غرام /م^3) مقارنة بدور الطباعة . سجل أعلى تركيز للمواد الدقائقية الناعمة ($PM_{2.5}$) التي يكون قطرها أقل من 2.5 مايكرو متر(44.50 مايكرو غرام /م^3) في دور الطباعة يليها أعلى تركيز للمواد الدقائقية الخشنة المستنشقة (PM_{10}) التي يتراوح قطرها بين 2.5 الى 10 مايكرو متر والدقائق الكلية العالقة (477.66 و667.00 مايكرو غرام /م^3) في دور الطباعة على التوالي . أظهرت النتائج أعلى تركيز لغاز أول أكسيد الكربون CO (6.13 جزء في المليون) والمركبات العضوية المتطايرة (VOCs) (21.88 جزء في المليون) في دور الطباعة بينما سجل أعلى تركيز لغاز ثنائي أكسيد النتروجين (NO_2) (1.44 جزء في المليون) في مراكز الاستنساخ . تجاوزت تركيز الرصاص والزنك والنحاس والمواد الدقائقية $PM_{2.5}$وPM_1 والدقائق الكلية العالقة المستويات المسموح بها في جميع مواقع الدراسة على عكس مستويات أول أكسيد الكربون وثنائي أكسيد النتروجين وثنائي أكسيد الكبريت والمركبات العضوية المتطايرة التي كانت ضمن محددات جودة الهواء المسموح بها .

الكلمات المفتاحية : جودة الهواء الداخلي ،آلات الاستنساخ، المواد الدقائقية ، العناصر الثقيلة ، المركبات العضوية المتطايرة