

THE RELATIONSHIP BETWEEN THE NUMBER OF PRINTED PAPER AND THE AMOUNT OF BENZENE RELEASED FROM THE LASER PRINTER.

Sivapan Choo-In^{*}, Paiboon Jeamponk^{} & Sudarat Seachai^{***}**
Environmental Science Department, Faculty of Science and Technology
Suan Sunandha Rajabhat University, Bangkok, Thailand.
E-mail: ^{} Sivapan.ch@ssru.ac.th, ^{**} paiboon.je@ssru.ac.th*

ABSTRACT

The objective of this research is to study the relationship between the amount of paper and the amount of benzene released from the laser printer while printing. The benzene were collected by the Coconut Shell Charcoal Tube and analyzed by Gas Chromatography/ Flame Ionization Detector (GC/FID), The results of the study showed that the benzene concentration released from the printer during printing (30 samples) was in the range of 0.0467 - 0.0506 micrograms per cubic meter. The benzene concentration emitted from the laser printer does not exceed the standard value (allow to receive 25 ppm). The resulted of the relationship between the paper and the benzene concentration released from the laser printer while printing documents It is found that the amount of paper and the benzene concentration released from the laser printer were relate at very high level at the .01 Significance level. Considering that as the amount of paper increases, the benzene concentration also increases.

Keyword : Bonzene, Lazer printer. Indoor air pollution

INTRODUCTION

Today, printing equipment plays an important role in operations and studies, such as photocopiers, faxes, printers, etc., which help facilitate work and learning. Especially, the printer is an information technology tool that has been very popular. Laser printers are widely used because they can print quickly. High print quality And the printed work that looks beautiful But the factor that cannot be ignored is The indoor air quality from the operation of a laser printer And the pollution that is emitted from a laser printer Which directly affects the health of users during the operation of such equipment Printing equipment, including printer, scanner, fax machine, photocopy, during the operation of the said device Causing an effect which causes the distribution of volatile organic compounds in the work area And a survey of the newspaper industry in the United States found that More than 100,000 kilograms of ink are used per year and has spread more than 8,000 kilograms of volatile organic compounds from solvents in printing ink [1].

1. Benzene

Benzene is a substance in the BTEX group consisting of Benzene, Toluene, Ethyl benzene, Xylenes and Styrene. This group is widely used in many industries, such as the petroleum industry, the production of paints, inks, as well as components of thinner, lacquer, adhesives and cleaning products, etc., are Volatile Organic Compounds or VOCs. Spread Each Distribution of volatile organic compounds from solvents (Solvent) inks in the printing process by evaporation. Volatile organic substances released into the atmosphere from the printer include benzene, toluene, ethyl benzene, dichloromethane, 1,1,1-trichlorethane, xylene, polystyrene,

chloroform. Laser printers are extremely hot during printing operations. For this reason, it results in the most volatile organic compounds compared to other printers [2].

The spread of volatile organic compounds affects the indoor environment and the health of those exposed. Which has both acute and chronic effects. It's causes asthma respiratory disease, if entering the body at a low level and many substances are addictive substances which have a central nervous system effect. It also causes eye irritation. Irritating to skin and tissue. If accumulated in the body for a long time, it will eventually damage the pleura. In particular, it is the cause of the Sick building syndrome [3]. Many volatile organic substances are released from the printer, especially benzene, exposure to respiratory. At a high concentration in a short time (acute toxicity) causing depression of the central nervous system and eventually death. While exposure to benzene at low concentrations for a long time (chronic toxicity) causes toxicity to the blood system The immune system and tumor associated with an increased risk of leukemia.

Benzene has been an important and widespread environmental pollutant. Exposure to benzene occurs via the inhalation of contaminated air. The International Agency for Research on Cancer (IARC) classifies benzene as a “human carcinogen” (group 1), with “sufficient” evidence of causing different types of leukemia, particularly, the acute myeloid form both in humans and in animals [4].

Benzene has clear, colorless liquid. It has a unique pungent odor, volatile, flammable, has easily vaporization. The vapor pressure up to 100 mmHg at 26.1 °C. Therefore, the contamination of benzene in water and soil is low concentration because benzene evaporates into the atmosphere quickly.

2. Benzene toxicity

Respiratory and eating benzene exposure at high concentrations in a short time (Acute toxicity) causing depression of the central nervous system and eventually death. While exposure to benzene at low concentrations for a long time (Chronic toxicity) causes toxicity to the blood system, immune system and tumors. Which are associated with an increased chance of leukemia.

1. Acute toxicity exposure to benzene at high concentrations by respiration resulting in pressure from the central nervous system arrhythmia cause drowsiness, dizzy, rapid breathing, headache, palpitations, dizziness, unconsciousness, and death due to respiratory failure. Eating at high concentrations causing stagnation, nausea, vomiting, stomach irritation, pneumonia, rapid pulse, rapid breathing, fainting, dizziness, intoxication, seizures, unconsciousness, and death due to central nervous system failure. Food intake at high concentrations but not high until life will cause dizziness the vision is disturbed. Symptoms are similar to excitement, pale face, redness, shortness of breath, headache, fatigue and drowsiness. If benzene is directly exposed through the skin may cause redness burning sensation, eye irritation. If repeatedly touching for a long time is related to the formation of dry skin platelet or caused by infection. If benzene comes into contact with the eyes, it may cause irritation and damage the cornea. In addition, studies by the Pollution Control Department, show in table1.

Table 1. The toxicity of benzene that affects various concentrations [5]

Benzene Concentration (ppm)	Received time	Symptoms toxic to humans
20,000	5-10 min	Lethal
7,500	30 min	Danger to life (could die)
1,500	60 min	Causing various serious symptoms
50-150	5 hr.	Headache, fatigue
25	8 hr.	No observed symptoms

2. **Chronic Toxicity** Chronic toxicity from benzene exposure that low concentrations for a long time stimulate the production of blood products such as red blood cells, white blood cells, leading to aplastic anemia, leucopenia, pancytopenia and thrombocytopenia. weakened immune system and may have a slight headache, nausea, anorexia and stomach discomfort. If there is a severe toxicity, fatigue may occur.

3. Benzene standard values in the work environment

According to the announcement of the Ministry of Labour, Thailand. In relation to the environment (chemicals), according to the Announcement of the Revolutionary Council No. 103 dated March 16, 1972, states that employees are prohibited to work in concentrated areas of chemicals. More than specified is the average concentration throughout the normal operating time is 10 ppm. The maximum concentration of benzene is 50 ppm. The duration is determined work for 10 minutes and could allow the concentration was equal to 25 ppm [5].

4. Laser printer

Laser printers rely on the same electrostatic technology as normal photocopiers, with light from the diode laser projected onto a rotating mirror to reflect on the photosensitive roller. Which will be adjusted according to the picture signal or characters received from the computer and swept the longitudinal rollers quickly. The coating on the roller reacts with light and then transforms it into static electricity. This causes the toner to adhere to the charged area. When the printing paper spins through the heat rollers, the toner will melt and adhere to the image or text. Because the laser beam is correctly controlled Causing the resolution of the image spot on the paper to be very high The print quality is therefore high, resulting in beautiful images and text. The printing of the laser printer is not loud.

The Volatile Organic Compounds (VOCs) in the printing were sampling by diffusive sampling method. The VOCs concentration were analyzed using GC / FID. There are 5 substances that have the highest concentration in the atmosphere are 1,1,1-Trichloroethane, Carbon tetrachloride, cis-1,2 -Dichloroethene, Toluene and 1, 2-Dichloropropane [6].

Study on indoor air pollution, by measuring the pollution caused by the use of copiers and printers within the office building Volatile organic compounds, such as benzene, toluene and ozone, were found in amounts that exceeded the international standard, causing effects on the respiratory system. Nasal irritation Irritation in the respiratory tract and may cause allergic rashes on the skin because when copying or printing documents, the substances in the toner powder when heated will evaporate. The resulted of this studies shown that each type of copier and printer releases these toxins differently depending on the environment. If the location of the copier is in a blind spot without sufficient ventilation, it will cause more air pollution than the area with ventilation [7].

The differences in the amount of dust less than 10 microns emitted from printers that use genuine and reused cartridges. The results show that the amount of dust smaller than 10 microns emitted from a printer using 30 genuine ink cartridges is in the range 166.67 - 3166.67 micrograms per cubic meter. With an average amount of dust of 1355.56 micrograms per cubic meter and from printers using 30 reuse ink cartridges in the range 1500.00 - 5000.00 micrograms per cubic meter. With an average amount of dust of 2861.11 micrograms per cubic meter [8].

The air pollution in offices which differed by device type such as laser printer, Inject printer, Scanner, Fax machine and Photocopy. The study found that the highest detected substances are Toluene, Styrene, Ethylbenzene, m, p-Xylene and have the following mean values of 15.3 ppb, 1.99 ppb, 1.56 ppb and 3.19 ppb, respectively. Higher concentration than Inject printer [9].

The indoor air monitoring of rooms with laser and inkjet printers. By analyzing VOCs, ozone and small dust particles The results showed that 3 types of VOCs were Styrene, m, p-Xylene and o-xylene. The concentration increased to 150 - 200 mg / M³. Ozone concentration increased from 1.5 to 6 ppb and the amount of small dust particles in the printing process. Through the processing of the printer, a particle size of approximately 50 nanometers. The concentration of particles increases dramatically during printing [10].

The study on particle emission for commercial color laser printers with 5, 24, and 38 pages of different prints in a 5 cubic meter laboratory. Commercial particle release of color laser printers when there is a large amount of paper to print will cause a lot of particles released from the printer. On the other hand, printing with a small amount of paper will result in less particles released from the printer. The highest particle emission from printers is printing 38, 24 and 5 pages, which results in 1.97×10^{-4} , 0.27×10^{-4} and 0.23×10^{-4} mg / print⁻¹ respectively [11].

OBJECTIVES

1. To study the amount of benzene released from the printer during document printing and compare with the safety standards in the work environment.
2. To study the relationship between the amount of printed paper and the amount of benzene released from a laser printer while printing a document.

RESEARCH METHODOLOGY

1. Research Instrument

- (1) Instrument
 - (1.1) HP laser jet P1006 printer
 - (1.2) Reused cartridge
 - (1.3) 80 grams A4 paper
 - (1.4) Coconut Shell Charcoal Tube
 - (1.5) Air sampling pump
 - (1.6) Machine for flow rate calibration
 - (1.7) Gas chromatography: flame ionization technique (GC / FID)
 - (1.8) Printer cover box
- (2) Reagent
 - (2.1) Benzene standard solution
 - (2.2) Carbon disulfide

2. Benzene Sampling

The study of the relationship between the number of printed paper and the benzene concentration released from the laser printer. There are operating procedures as follows

- (1) Installing air suction pump Samples were collected using air sampling tubes. From the HP laser jet model P1006, initial measurement is performed before printing.
- (2) Conducting a sample collection during printing and after printing is complete. Continuous printing, add 2 sheets to 60 sheets of paper, 30 samples, set the time for each sample to 10 minutes. Repeat 2 samples.
- (3) Take the air sampling tube to analyze the benzene content by Gas Chromatography/Flame Ionization Detector: GC / FID.
- (4) Analyzing the relationship between the amount of printed paper and the amount of benzene released from the laser printer by using the Pearson correlation coefficient, at .05 significant level.

RESEARCH RESULT AND DISCUSSIONS

1. The amount of benzene released from the printer while printing documents.

The results of the benzene emission from laser printers during printing with analysis results Show details as in Table 2 and figure 1 as follows

Table 2. The amount of benzene concentration released from the laser printer while printing.

order	Number of paper (sheets)	Benzene Concentration ($\mu\text{g}/\text{m}^3$)		
		No 1	No 2	Average
1	2	4.5723×10^{-5}	4.7616×10^{-5}	0.0467
2	4	4.6149×10^{-5}	4.7709×10^{-5}	0.0469
3	6	4.6556×10^{-5}	4.7766×10^{-5}	0.0472
4	8	4.7043×10^{-5}	4.7802×10^{-5}	0.0474
5	10	4.7588×10^{-5}	4.7803×10^{-5}	0.0477
6	12	4.7603×10^{-5}	4.7993×10^{-5}	0.0478
7	14	4.7611×10^{-5}	4.8002×10^{-5}	0.0478
8	16	4.7853×10^{-5}	4.8019×10^{-5}	0.0479
9	18	4.8032×10^{-5}	4.8108×10^{-5}	0.0481
10	20	4.8281×10^{-5}	4.8256×10^{-5}	0.0483
11	22	4.8297×10^{-5}	4.8327×10^{-5}	0.0483
12	24	4.8458×10^{-5}	4.8349×10^{-5}	0.0484
13	26	4.8460×10^{-5}	4.8433×10^{-5}	0.0484
14	28	4.8492×10^{-5}	4.8502×10^{-5}	0.0485
15	30	4.8498×10^{-5}	4.8559×10^{-5}	0.0485
16	32	4.8503×10^{-5}	4.8566×10^{-5}	0.0485
17	34	4.8510×10^{-5}	4.8674×10^{-5}	0.0486
18	36	4.8556×10^{-5}	4.8679×10^{-5}	0.0486
19	38	4.8613×10^{-5}	4.8685×10^{-5}	0.0486
20	40	4.8843×10^{-5}	4.8703×10^{-5}	0.0488
21	42	4.8986×10^{-5}	4.8780×10^{-5}	0.0489
22	44	4.9002×10^{-5}	4.884×10^{-5}	0.0489
23	46	4.9138×10^{-5}	4.8964×10^{-5}	0.0491
24	48	4.9286×10^{-5}	4.9181×10^{-5}	0.0492
25	50	4.9486×10^{-5}	4.9188×10^{-5}	0.0493
26	52	4.9649×10^{-5}	4.9291×10^{-5}	0.0495
27	54	4.9723×10^{-5}	4.9350×10^{-5}	0.0495
28	56	4.9903×10^{-5}	4.9577×10^{-5}	0.0497
29	58	5.0578×10^{-5}	4.9687×10^{-5}	0.0501
30	60	5.0762×10^{-5}	5.0439×10^{-5}	0.0506

From Table 2, it is found that the benzene concentration released from a laser printer while printing. The lowest average value was 0.0467 micrograms per cubic meter by printing 2 sheets and having an average of 0.0506 micrograms per cubic meter by printing 60 sheets.

The results compare benzene concentration with the standard working environment. According to the announcement of the Ministry of Interior regarding work safety regarding the environment that has been defined as "The maximum concentration of benzene for a limited time The time limit for working 10 minutes should not be more than 50 ppm concentration. The benzene concentration that can be analyzed is in the range 1.460×10^{-5} - 1.584×10^{-5} ppm, which does not exceed the standard value announced by Ministry of Labor.

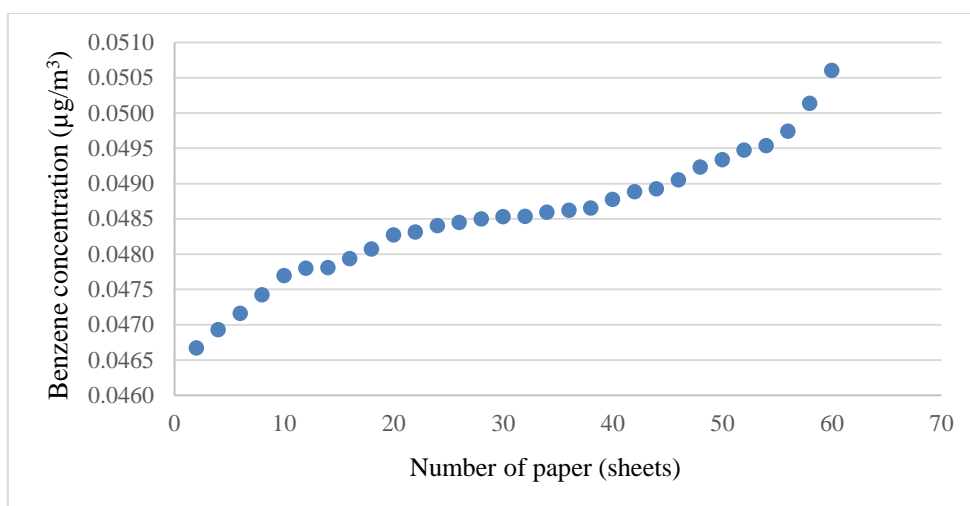


Figure 1. The amount of benzene released from the printer during document printing.

From the picture 1, It can be explained that the amount of benzene released from the printer during the printing of 30 documents increases steadily with the amount of paper being used. The average minimum benzene concentration was 0.0467 micrograms per cubic meter from printing 2 sheets and the highest average benzene concentration was 0.0506 micrograms per cubic meter from printing 60 sheets.

2. The study of the relationship between the number of printed paper and the amount of benzene released from the laser printer while printing documents

Statistical analysis results to find the relationship between the number of printed paper and the amount of benzene released from the laser printer are shown in Table 3.

Table 3. Results of the relationship between the amount of printed paper and the amount of benzene released from Laser printers while printing.

parameter	N	Correlation (r)	Sig.(2-tailed)
Number of paper	30	.968	.000*
Benzene concentration	30		

* Correlation is significant at the 0.01 level (2-tailed).

From table 3, Sig is .000. The amount of paper printed and the amount of benzene released from the laser printer are related at the significant level of .01 with the correlation coefficient (r) equal to .968 which, when analyzed with table 4, can explain that The amount of paper printed and the amount of benzene released from the laser printer are positively high.

Table 4. Level of relationship [12]

the correlation coefficient (r)	Level of relationship
0.91 – 1.00	There is a very high relationship.
0.71 – 0.90	There is a high level of relationship.
0.51 – 0.70	There is a moderate relationship.
0.31 – 0.50	There is a low relationship.
0.00 – 0.31	There is a very low relationship.

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