GRID 2022
11 . INTERNATIONAL SYMPOSIUM
GRAPHIC ENGINEERING AND DESIGN
03-05. NOVEMBER 2022

11th GRID SYMPOSIUM

Contribution of flexographic printing process to ground-level ozone concentrations

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Introduction

Printing materials, such as printing inks and solvent-based cleaners used in the machine cleaning process, cause the release of ozone and volatile organic compounds and contribute to air pollution.
Solvent-based inks are widely used in the flexographic printing process because these inks dry by evaporation. Unfortunately, the flexographic solvents usually contain significant VOCs, which have notable health and safety concerns. Also, VOCs contribute to the formation of ground-level ozone, which causes substantial respiratory and other health problems. When stratospheric ozone is found in the lower layers of the atmosphere, it is considered a pollutant.

Problem description

The quantitative concentration levels of ground-level ozone emitted due to the flexographic printing process are presented in this paper.
Also, the obtained ozone concentrations were compared to the emission limit value prescribed by the Regulation of the Republic of Serbia.

Methods

Flexographic printing plant

Measurements of ground-level ozone concentration were carried out in a flexographic printing plant located on the territory of Novi Sad. The flexographic printing machine, model No: JXG 6750 (manufactured by Shenzhen Fungshengtai Industry CO., LTP, China), was used to print polymer bags.

Analysis of ground-level ozone in the flexographic printing plant

The potassium-iodide method was used to determine ground-level ozone in the air of a flexographic printing plant. The air with ground-level ozone was collected with a PRO-EKOS AT-401X sampler with four Drechsel gas washing bottles with filter disks. The air from the printing house was passed through the Drechsel bottles at a speed of 0.5 dm^3/min. Also, the absorption solution for ground-level ozone (10 ml of 1% potassium iodide in 1 M sodium hydroxide) was found in the Drechsel glass washer. After the sampling, an acidified reagent (5 g of sulfamic acid, 84 cm^3 of 85% phosphoric acid, and distilled water up to 200 cm^3) was added to the absorption solution.
The prepared solution was well stirred and allowed to cool to room temperature. A stable compound was formed, which could be stored for several days. The analysis was completed in the laboratory by adding a phosphorus-sulfamine reagent, which releases iodine. The absorptions of the yellow-colored ground-level ozone solutions were determined by UV/VIS spectrophotometer DR 5000 at 352 nm.

Campaigns 1 and 2 were carried out after four and eight hours of working time, respectively. In each campaign, absorption samples of ground-level ozone were collected simultaneously in four Drechsel gas washing bottles. The concentration (µg/m^3) of ground-level ozone in the flexographic printing plant (in campaigns 1 and 2) was determined according to the formula (1):

$$C(O_3) = \frac{(\mu g/10\ cm^3 \quad O_3)1000}{V_{kor}} \qquad (1)$$

Where, V_{kor} is the volume of sampled air corrected to standard conditions (temperature of 25°C and pressure of 101325 Pa).

Results

Concentration levels of ground-level ozone in the flexographic printing plant in campaigns 1 and 2 for first Drechsel gas washing bottles during five days of monitoring are shown in Figure 1.

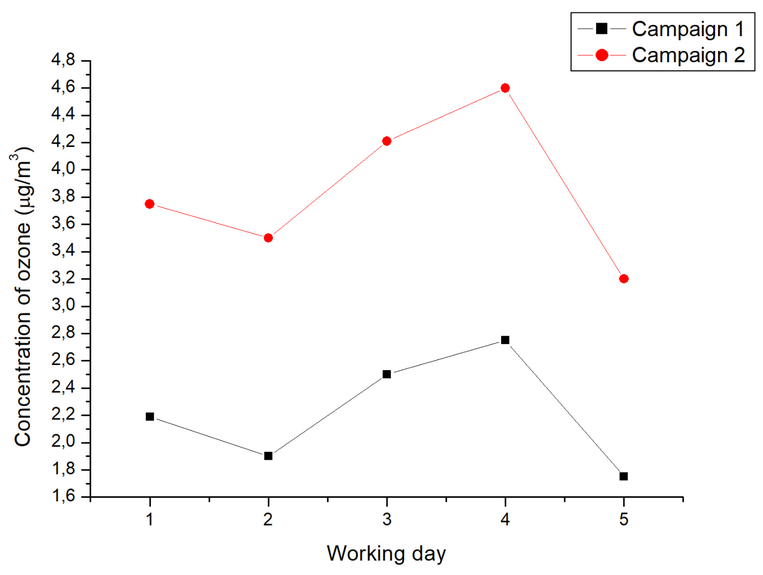

Figure 1
Comparison of ground-level ozone concentrations in the flexographic printing plant in campaigns 1 and 2 for the first Drechsel gas washing bottles

The obtained results show that in campaign 1, the concentration levels of ground ozone were in the intervals: from 2.20 to 2.75 µg/m^3 (on the 4th day), from 2.35 to 2.65 µg/m^3 (on the 3rd day), from 2.10 to 2.30 µg/m^3 (1st day), from 1.80 to 2.00 µg/m^3 (2nd day), and from 1.60 to 1.80 µg/m^3 (5th day).
In campaign 2, the ground ozone concentration levels decreased from: 4.60 to 4.80, 4.15 to 4.32, 3.75 to 3.90, 3.50 to 3.70, 3.10 to 3.30 µg/m^3 for the 4 th, 3rd, 1st, 2nd, and 5th days, respectively.
The mean values of ground-level ozone concentrations from the 1st to the 5th day of monitoring were 2.19, 1.89, 2.48, 2.47, and 1.72 µg/m^3 (campaign 1) and 3.81, 3.60, 4.25, 4.71, and 3.18 µg/m^3 (campaign 2).

By comparison, the stated values in campaigns 1 and 2 for the same day increased from 42 to 48%. As expected, after 8 hours of work and with the increase in the volume of flexographic production, ground-level ozone concentrations are more than 1.7-1.9 times compared to the values after 4 hours.

Discussion / Conclusion

The results of the five-day analysis show that the flexographic plant produces ground-level ozone. Based on the measured ground-level ozone concentrations of the flexographic printing plant, the following conclusions were drawn:

- In the campaign conducted in the middle of working hours, ground-level ozone concentrations are from 1.60 to 2.75 µg/m^3. At the end of the eight-hour working time, ground-level ozone concentrations are from 3.10 to 4.80 µg/m^3.
- Concentration levels during the working week decrease in an order: 4th > 3rd > 1st > 2nd > 5th day of monitoring in both campaigns.
- As expected, ground-level ozone concentrations are increasing with the increase in the volume of flexographic production.

According to the Regulation on monitoring conditions and air quality requirements of the Republic of Serbia, the limit value for ground-level ozone is 150 µg/m^3 for 1 hour of monitoring. However, the analysis of ground-level ozone produced by the flexographic printing plant in the middle and at the end of the eight-hour working time during the five-day shows that the highest measured values were from 32 to 47 times lower than the limit value.

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ACKNOWLEDGMENTS

The authors acknowledge the financial support of the Ministry of Education, Science and Technological Development, Republic of Serbia through the project no. 451-03-68/2020-14/200156: "Innovative scientific and artistic research from the FTS (activity) domain".