# The Impact Factors of the Environmental Pollution and Workers Health in Printing Industry

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*Abstract*—This paper presents the study of parameters affecting the environment protection in the printing industry. The paper has also compared LCA studies performed within the printing industry in order to identify common practices, limitations, areas for improvement, and opportunities for standardization. This comparison is focused on the data sources and methodologies used in the printing pollutants register. The presented concepts, methodology and results represent the contribution to the sustainable development management. Furthermore, the paper analyzes the result of the quantitative identification of hazardous substances emitted in printing industry of Novi Sad.

*Keywords*—LCA, parameters of pollution, printing industry, register

## I. INTRODUCTION

WITHIN the printing industry, one of the primary problems in production is non-standardized assumptions and practices. This makes it difficult, if not impossible, uniquely determine the lifetime of company [1]. Printing is an ubiquitous part of our lives, ranging from the printing of personal documents and photos, to the documents we use to communicate in business and the mass production of advertisements, marketing, and magazines. Given the pervasiveness of print, it is not surprising that many organizations are interested in the environmental impacts associated with printing through its life duration. These include impacts such as toxic pollution, water consumption, energy consumption, solid waste production, and air pollution. In the early seventies of the 20th century, a systematic study and monitoring of pollution and environmental protection have begun. Nowadays, due to the development of management practice, there is a perceived need to provide a healthy living environment for future generations.

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Development as a process of work reproduction is permeated through all segments of society, and its successful implementation requires good governance, or broadly speaking good management [1]. Despite the standards and certification programs, there is still a great deal of uncertainty and disagreement about the interpretation of the many LCA studies in the printing industry.

Life cycle assessment (LCA) is a way to evaluate the impact of various aspects associated with development of product and its potential impact on the environment throughout its life [2], [3]. LCA includes definition of goal and scope, inventory analysis, impact assessment and interpretation of results [2], [4]–[6]. The goal and scope definition describes the underlying question (objective), the system, its boundaries and the definition of a functional unit. The flows of pollutants, materials and resources are recorded in inventory analysis. These elementary flows (emissions, resource consumption, etc.) are characterized and aggregated for different environmental problems in impact assessment and finally conclusions are drawn in interpretation stage. LCA applications are comparisons of different products and systems, or different materials production or recycling methods. LCA can be used as a tool to detect potentials for improvements with the aim to reduce the impact on human health, environment and resource depletion.

The studies that are in scope of this paper are in the domain of printing industry as a relatively low source polluter of the environment, but the presented concepts, methodology and results are the authors' contribution to the sustainable development management.

## II. RESEARCH BACKGROUND

The research was carried out in the printing industry of Novi Sad, and resulted in the compilation of the polluters and pollutants register. The basics of the process are presented in the paper.

### A. Pollutants register

Register of pollutants presents a list of information and data of the pollutants that are harmful to the environment and provides the basis for their monitoring and control [7], [8]. It contains information about contaminants, their location, production processes, preferences and material balances of inputs and outputs of raw materials in waste water treatment, other types of waste and landfills [7], [8]. The aim of the register of hazardous materials results from the need for obtaining quality and timely information about environmental pollution released from printing facilities.

*The started objectives include:*

- Identification of individual sources of pollutants;
- Reducing pollution from industrial facilities and other sources to minimum;
- Determination of the amount and trend monitoring of specific pollutants emission due to lower the risk level of adverse effects;
- Improvement of public access to information, as well as its involvement in the process of decision making on environmental issues.

The Register is an important database for decision making and provides significant basis for preventing pollution in printing industry. It allows government agencies to identify the emission of pollutants, monitor progress in pollution prevention and thus, implement and carry out environmental policy, identify priorities and perform necessary actions towards integrated environmental protection, all in the function of sustainable development management.The Registry is an integral part of information system for environmental protection of the Republic of Serbia, which is in direction of the Agency for Environmental Protection. It is in accordance with the Law and contains data about air and water pollution and waste management from point sources as well as the settlement, as diffuse sources [8].The companies which should make report about pollutants emission from their facility are determined by the Fig. 1.
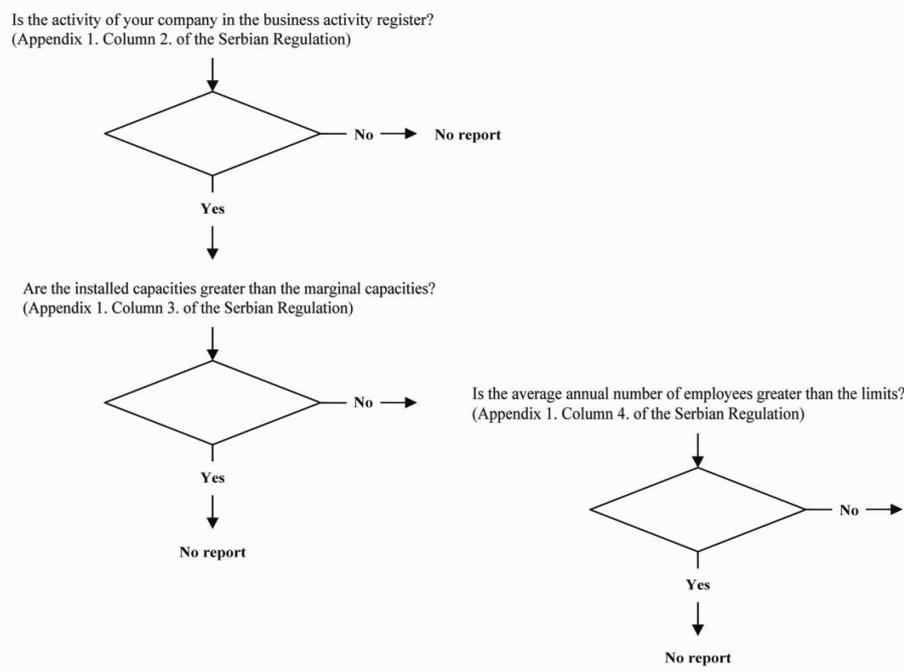


Fig. 1 Reporting of companies for the Register of pollutants

The Register provides an important mechanism for increasing company's responsibility, pollution reduction and promotion of sustainable development [9]. During the process of data collection for the Registry of pollutants, managers in many companies found that emissions were not only the problem of environmental pollution, but also a significant source of lost funds.As a result of data collection from source emissions, companies started different research due to find a variety of technical and technological solutions that significantly decreased the level of impact of environmental pollution, reduced all types of emissions from the source by using alternative fuel, less hazardous chemicals and mineral resources, improved production process control and increased equipment efficiency.

III. RESULTS

*A. Quantitative identification of hazard in printing industry of Novi Sad*

Based on the data collected in the field and classified in the real conditions of selected printing facilities operation, the appropriate substitution of the individual toxic substances in the mixtures of solvents are proposed with eco-friendly solvents, whose physical and chemical characteristics have benefit impact on profitability and efficiency of the technological processes, as well as on the quality of living and working environment [10], [11].Quantitative analyses of the presence of certain pollutants were carried out by using different physical and chemical methods and instruments: mobile gas chromatograph Voyager, Photovac, Inc., portable ozonometer Aeroqual Series 200, Aeroqual Ltd., mass spectrometer Perkin Elmer Elan 5000 with inductively coupled plasma and sound level meter TES-1358A with RS-232 interface [12].

Real-time measurements of VOCs, isopropanol, acetone, ozone and formaldehyde concentrations were performed in the screen printing facilities in Novi Sad, Table I.

TABLE I
CONCENTRATION RANGE OF SCREEN PRINTING INDOOR POLLUTANTS

| Substances | C (ppm) | MAC (ppm) | | | |
|---|---|---|---|---|---|
| | | OSHA | | NIOSH | |
| | | PEL | STEL | REL | IDLH |
| Acetone | 0.013 to 0.150 | 1000 | 1000 | 250 | 2500 |
| Isopropanol | 0.059 to 0.112 | 400 | 500 | 400 | 2000 |
| Methyl ethyl ketone | 0.171 to 0.195 | 200 | 300 | 200 | 3000 |
| Formaldehyde | 0.413 to 0.836 | 0.75 | 2 | 0.016 | 20 |
| Ozone | 0.839 to 2.778 | 0.1 | 0.3 | 0.1 | 5 |
| o-xylene | 0.253 | 100 | 150 | 100 | 900 |
| Toluene | 0.017 to 35.459 | 200 | 300 | 100 | 500 |
| Benzene | 0.022 | 1 | 5 | 0.1 | 500 |

Concentration levels of target VOCs are within the framework of the permissible exposure limit (PEL) for 8-hour time-weighted average recommended by the Occupational Safety and Health Administration (OSHA) [12].

The average values of formaldehyde concentrations measured in the screen printing facilities were in the range from 0.413 to 0.836 ppm which are below to prescribed OSHA standards. Variations of formaldehyde concentrations are related to the chemical compositions of raw materials, ambient conditions, and distance from the printing machine, as well as type of air filtration system installed in the printing machine [12].

Experimental results showed that ambient ozone concentrations raise with the increase of total volatile organic compounds (TVOCs) concentration [12]. According to the Serbian Regulation the maximum allowed concentration (MAC) of ozone emission in workplace is 0.05 ppm, but measured ozone concentrations (0.839 to 2.778 ppm) is much more above prescribed MAC value, Fig. 2 [13].

The liquid waste of printing industry contains large amounts of organic compounds. The problem of printing wastewater pollution is solved with adsorption on natural low-cost adsorbents such as zeolite-clinoptilolite (NZ), activated carbon (AC) and their mixture (NZ+AC), Table II [14].
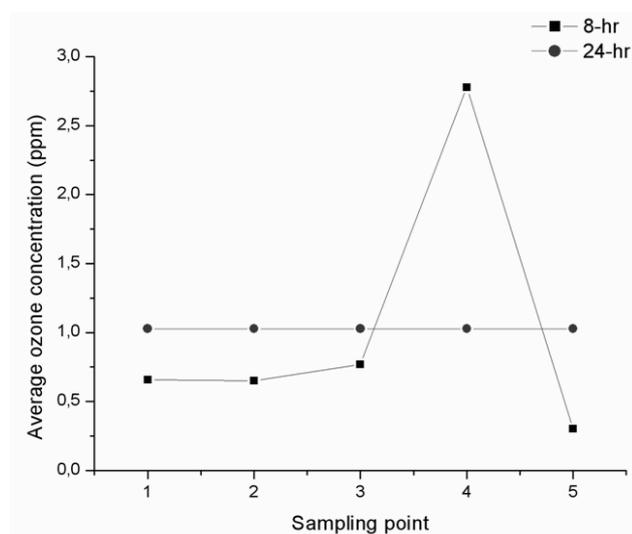


Fig. 2 Average ozone concentrations during 8-hr and 24-hr measurements [19]

The efficiency of printing wastewater purification is accompanied by immobilization of metal ions during the contact time. The results showed the efficiency of adsorbents in the following order: AC > NZ > NZ+AC.

TABLE II
CONCENTRATION LEVELS OF ZN(II) IONS IN PRINTING DEVELOPER BEFORE AND AFTER ADSORPTION

| Before adsorption | | After adsorption | | |
|---|---|---|---|---|
| Fresh developer | Spent developer | AC* | NZ* | NZ+AC* |
| 1.278 ± 0.064 | 17.302 ± 0.865 | 6.233 ± 0.312 | 7.624 ± 0.381 | 9.567 ± 0.478 |

∗ Spent printing developer after adsorption on AC, NZ and NZ+AC

The level of noise, as psychological and physical pollutant, was measured in the offset printing facility. It was observed that the highest level of noise is produced by offset printing machines and folding units [15], but does not exceed the permitted level according to the Regulation of the level of noise in environment of 75 dBA.

IV. CONCLUSION

Starting from the importance and role of sustainable development in human life, and bearing in mind that the made the research that resulted in the process of creating database of hazardous substances in the printing industry of Novi Sad as a background of sustainable development management, and thus, Novi Sad and the Republic of Serbia successfully satisfied a part of the imposed conditions for European integration. Based on the obtained experimental data, the Register of pollutants of printing facilities on the territory of Novi Sad was drawn up.

A great deal of activity is occurring in environmental impact assessment within the printing industry. It is clear that a great deal of effort and expense has been put into these assessments. While each of these analyses has served specific purposes, the printing industry has expressed the need to be able to make meaningful comparisons across studies. The

analysis performed in this work has not only confirmed the inability to make cross-comparisons across studies, but has also identified sources of discrepancies and variability.

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