

## EFFECTS OF OCCUPATIONAL EXPOSURE TO SOME IRRITATIVE POLLUTANTS UPON THE LUNG FUNCTION

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**Abstract. Aim:** To study the occupational exposure effects of some irritative pollutants (IP) upon the pulmonary function, in the cellulose fibres industry. **Methods:** Cross-sectional occupational study on 117 workers exposed to IP mixtures versus matched controls. IP assessments have been done in the workplaces air. Health status investigations comprised clinical examinations and laboratory tests, as well as computerised assessment of the pulmonary capacities and flows (VC, FVC, FEV<sub>1</sub>, FEV<sub>1</sub>/VC, FEF<sub>0.2-1.2</sub>, FEF<sub>25-75%</sub>, PEF, MEF<sub>50%</sub>, MEF<sub>25%</sub>, MEF<sub>75%</sub>). **Results:** The IP measurements in the workplaces air showed under TLV values. Health status assessment revealed significant increase of obstructive dysfunction associated with IP occupational exposure (Yate's  $\chi^2=57.24$  p:0.000000, OR=8.96, 95%CI: 4.98-16.11). In the exposed, 37% of subjects had FEV<sub>1</sub> and FEV<sub>1</sub>/VC in normal limits, the other parameters indicating distal obstructive syndrome (DOS), the majority of cases having more severe obstructions: 41% slight obstructions (SO) and 4.3% moderate obstructions (MO). In the controls 16.4% subjects had DOS, 5.7% SO and 0% MO. The difference between these percentages was also statistically significant (p:0.0000-0.029). Further analysis allowed a more precise diagnosis of the obstruction degree in its early stage, and also showed some useful correlations with the levels of IP. **Conclusions:** The exposure to irritative pollutants, in occupational settings, could be involved in the impairment of pulmonary function, largely causing obstructive syndromes in the exposed people. The systematic use of pulmonary function testing allows precocious diagnosis and, consequently, adequate prophylactic measures.

**Key words:** irritative pollutants, computerised pulmonary testing, obstructive impairment, distal obstructive syndrome

**Rezumat. Scop:** Studiul efectelor expunerii ocupaționale la unii poluanți iritativi (PI), asupra funcției pulmonare, în industria fibrelor celulozice. **Metodologie:** Studiu epidemiologic transversal pe 117 muncitori expuși la PI, comparativ cu un lot martor adecvat. S-au evaluat PI în aerul locurilor de muncă și s-a studiat starea de sănătate prin examene clinico-paraclinice și prin spirometrie computerizată (CV, CVF, VEMS, IPB, DME<sub>0.2-1.2</sub>, DME<sub>25-75%</sub>, DEV, DEM<sub>50%</sub>, DEM<sub>25%</sub> și DEM<sub>75%</sub>). **Rezultate:** PI au avut valori sub CMA în aerul locurilor de muncă. Evaluarea stării de sănătate a relevat o prevalență semnificativ mai mare a disfuncțiilor obstructive, comparativ cu martorul, disfuncții asociate cu expunerea ocupațională la PI ( $\chi^2$  Yates =57.24 p:0.000000, OR=8.96, 95%CI: 4.98-16.11). 37% dintre expuși au avut VEMS și IPB în limite normale, ceilalți parametri ventilatori definind sindroame de obstrucție distală discretă (SODD). Majoritatea subiecților au avut obstrucții mai severe: 41% disfuncții ventilatorii obstructive (DVO) ușoare și 4,2% DVO medii. La martori, 16,4% persoane au avut SODD, 5,7% DVO ușoare și și 0% DVO medii. Diferențele dintre aceste procentaje au fost, de asemeni, statistic semnificative (p: 0.0000-0.029). Studiul datelor obținute a permis un diagnostic mai precis al stadiului obstrucției în fazele sale

precoce, și a arătat corelații utile cu nivelele PI. **Concluzii:** Expunerea ocupațională la PI poate fi implicată în alterarea funcției pulmonare, determinând sindroame obstructive la un mare număr dintre persoanele expuse. Utilizarea sistematică a PFV computerizate permite un diagnostic precoce și măsuri profilactice adecvate.

**Cuvinte cheie: poluanți iritativi, spirometrie computerizată, disfuncții obstructive, sindrom de obstrucție distală discretă**

## INTRODUCTION

In the cellulose fibres industry exists mixtures of irritative pollutants (sulphur dioxides, acid mists, sulphur hydride, mercaptans, and so on). The workers are exposed at these pollutants whose concentrations are, generally, under the threshold limit values (TLV). Although the working conditions seem to be in normal limits, one can see a lot of these workers having respiratory problems, especially of obstructive nature, as well as irritative airways syndromes (1,2,3). It appears that these specific pollutants have an intense irritative effect in this combination, possible by a cumulative mechanism and it also appears the necessity to thoroughly investigate the respiratory phenomena of the exposed workers in order to improve the working conditions as well as the health status.

The aim of this research was the study of the ventilatory dysfunction prevalence and of its specific qualitative and quantitative characteristics, in occupational exposure to irritative pollutants (IP) in the cellulose fibres industry. The main hypothesis, expressed as an alternative one, states that the IP exposure in the cellulose fibres industry has an irritative effect upon the exposed workers airways even at exposure levels under TLV; the effect consisting mainly in ventilatory dysfunction of obstructive type.

## MATERIAL AND METHODS

A cross - sectional study on 117 workers occupationally exposed to irritative pollutants, versus 122 well matched controls has been realised.

The exposed group (117 subjects: mean age =  $34.75 \pm 6.23$  years, mean length of service =  $12.31 \pm 5.10$  years) was comparable with control (122 subjects: mean age =  $35.71 \pm 7.01$  years, mean length of service =  $13.17 \pm 6.39$  years) for age and length of service homogeneity and distribution, as well as for the other potential confounding factors (smoking habits, alcohol and drug consumption, environmental exposure to respiratory irritative hazards). It is also to be mentioned that both groups have jobs with similar physical solicitation, live in the same town in similar polluted areas and have similar nutritional habits.

Exposure evaluations of each IP have been done in the air of each specific workplace, in the investigated cellulose fibres factory, in order to quantify as well as possible the pollutants concentrations and proportions for every workplace (4). According to the IP concentration levels, the workplaces were classified in three categories: A-high concentration, B-medium concentration and C-low concentration. The aim of this classification is to better correlate the exposure intensity with the degree of the observed effect.

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Clinical investigations (5,6) comprised, careful occupational and medical history, clinical examinations and computerised respiratory function tests. The ventilatory capacities and flows have been measured by means of a computerised spirometer (Schiller Switzerland SP200) with high sensibility pneumotachometric sensor and software able to do the BTPS correction and to compare the measured values with the predicted ones (ECCS Standards). The studied parameters of the lung ventilatory function have been Vital Capacity (VC), Forced Vital Capacity (FVC), Forced Expiratory Volume <sub>1.0 (sec)</sub> (FEV<sub>1</sub>), FEV<sub>1</sub>/VC, Forced Expiratory Flow <sub>0.2-1.2 (litres)</sub> (FEF<sub>0.2-1.2</sub>), Forced Expiratory Flow <sub>25-75%</sub> (FEF<sub>25-75%</sub>), Peak Expiratory Flow (PEF), Maximum Expiratory Flow <sub>50%, 25%, 75%</sub> (MEF<sub>50%</sub>, MEF<sub>25%</sub>, MEF<sub>75%</sub>) (7,8,9).

The diagnosis of the distal obstructive syndrome relies on the following parameters: FEF<sub>25-75%</sub> (measured on the forced expirogram curve, as well as FEV<sub>1</sub> and FVC), PEF, MEF<sub>50%</sub>, MEF<sub>25%</sub> and MEF<sub>75%</sub> (measured on the

flow-volume curve). These parameters are more sensitive than those applied in the routine spirographic exploration (FEV<sub>1</sub>, FEV<sub>1</sub>/VC) because they assess the ventilation efficiency in the conditions in which the force of respiratory muscles has a secondary role and, consequently, cannot hide the flow decrease due to the obstruction of the small pathways (less than 2 mm in diameter), (8,9).

The integrative assessment of the alteration degree of all these parameters has been realised by means of a method that establishes a multifactorial scale for a more precise estimation of the stage of the bronchial response versus the irritant agents.

STATISTICA and EPIINFO software were used for data processing.

RESULTS AND DISCUSSION

The IP concentrations in the workplaces air were under TLV. According to the above mentioned workplaces classification, the table 1 shows both the levels of IP for each workplace category, and the number of exposed subjects.

**Table 1. Categories of workplaces according to the IP concentration**

Category	Irritative Pollutants Levels (mg/m <sup>3</sup> )				No. of exposed Subjects
	SO <sub>2</sub>	HCl	H <sub>2</sub> SO <sub>4</sub>	Mercaptans	
A - High	3 - 5	2.5 - 3.8	0.35 - 0.6	0.5 - 0.8	31
B - Medium	2 - 3	1 - 2.5	0.1 - 0.35	0.2 - 0.5	59
C - Low	<2	<1	<0.1	<0.2	27

Clinical and especially spirometric investigations revealed that 71.8 % of the workers versus 22.13 % of the controls had obstructive dysfunctions. So, we found significant increase of obstructive dysfunctions associated with IP occupational exposure (Yates

$\chi^2=57.24$ , p:0.000000, OR=8.96 95% CI: 4.98-16.11). The distribution of obstructive dysfunctions is shown in table 2.

We also found significant increases of both Distal Obstructive Syndrome (Yates  $\chi^2=19.45$ , p=0.000010, OR=4.46,

**Table 2. Obstructive syndromes in exposed versus controls**

	Normal subjects	Obstructions			
		Total obstructions	Distal Obstructive syndrome FEV1 > 80% FEV1/VC > 80% FEF25-75%, MEF50%, MEF25%, PEF, MEF75%, < 80%	Slight obstructions FEV1 < 80% FEV1/VC < 80%	Moderate and severe obstructions FEV1 < 55%
Exposed workers	33	84	31	48	5
Controls	95	27	20	7	0

95%CI: 2.24 - 8.88) and slight obstructions (Yates  $\chi^2=58.96$ ,  $p=0.000000$ ,  $OR=19.74$ , 95%CI: 8.14 - 47.9) associated with IP occupational exposure. 37% of the obstructions at the exposed, had FEV 1 and FEV 1/VC in normal limits the other parameters indicating Distal Obstructive Syndrome (DOS), the majority of cases having more severe obstructions: 41% slight obstructions (SO) and 4.3% moderate obstructions (MO). 16,4% of the controls had DOS, 5.7% SO and 0% MO. The differences between these percentages was also statistically significant ( $p:0.0000-0.029$ ).

This statistical analysis points out a significant increase of obstruction prevalence as well as an increase of severity degree of this obstruction at the exposed subjects. The results sustain a casual relationship between

exposure to respiratory IP and airways obstructive reactions.

In order to put in evidence a dose effect relationship (which could further support the causality), an analysis of possible correlations between exposure levels (defined as high, medium and low - see above) and the discrete values of the ventilatory parameters has been done. The nature of studied variables allowed the calculation of nonparametric Spearman R correlation.

The following Spearman R correlation coefficients have been found (table 3). Although there are not strong correlations, they seem to further support the causality relationship postulated before. It also appears that FEF<sub>25-75%</sub>, MEF<sub>50%</sub> and MEF<sub>25%</sub> are better correlated with exposure.

**Table nr. 3: Measured parameters versus exposure levels**

Measured parameter	Spearman R	t (N-2)	p
FEF25 - 75 %	0.52	3.7	0.001
MEF50 %	0.44	3.1	0.004
MEF25 %	0.39	2.6	0.011
MEF75 %	0.32	2.1	0.04
PEF	0.26	1.9	0.06

These findings seem to also underline the diagnosis value of FEF<sub>25-75%</sub>, MEF<sub>50%</sub> and MEF<sub>25%</sub>, basic parameters, for the early stage of obstruction - DOS.

Besides, by studying the modified ventilatory parameters, their number

and the level of their changes (minor: 79 - 60 %, medium: 59 - 40 % and severe < 39 %), we have established more precisely the obstruction degree in its early stage. We have used a six degree scale of both certainty and severity

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ranging from the minor decrease of one parameter (usually  $MEF_{50\%}$  or  $FEF_{25-75\%}$ ) up to the medium decrease of all the parameters.

Thus we have found at lower exposure levels, especially for acid mists, a higher prevalence of slight changes (minor decreases of up to three parameters). At higher exposure levels moderate ventilatory changes, especially V and VI degree (medium decreases of at least two parameters, associated with minor decreases of the other parameters) prevailed.

In fact, this finding agrees with the previous correlation research, but this time the analysis emphasises the role of associations between various ventilatory parameters for the precocious positive diagnosis in the early stages of obstruction.

### CONCLUSIONS

This research confirms the studied hypothesis and seems to prove that occupational low level (under TLV) exposure to some irritative pollutants may cause, in cumulative conditions, an obstructive impairment of the lung function to the majority of the exposed workers in the cellulose fibre industry. It appears that even at levels under TLV both acid mists and mercaptans are the most irritative pollutants of these workplaces, acting possibly in a cumulative way.

The obstructive response of workers airways ranged from various degrees of DOS up to moderate ventilatory obstructions, which prevailed in the studied conditions as a consequence of

intensive irritative effect of these pollutants.

Considering the evolvable potential of obstructions, it is also to be mentioned the importance of studying the defining DOS parameters, which allows a quick and precocious diagnosis of this early stage of irritative obstructive disease and therefore allows precocious and more efficient prophylactic measures.

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