# Levels of carbohydrates in $PM_1$ particulate matter emitted during wintertime

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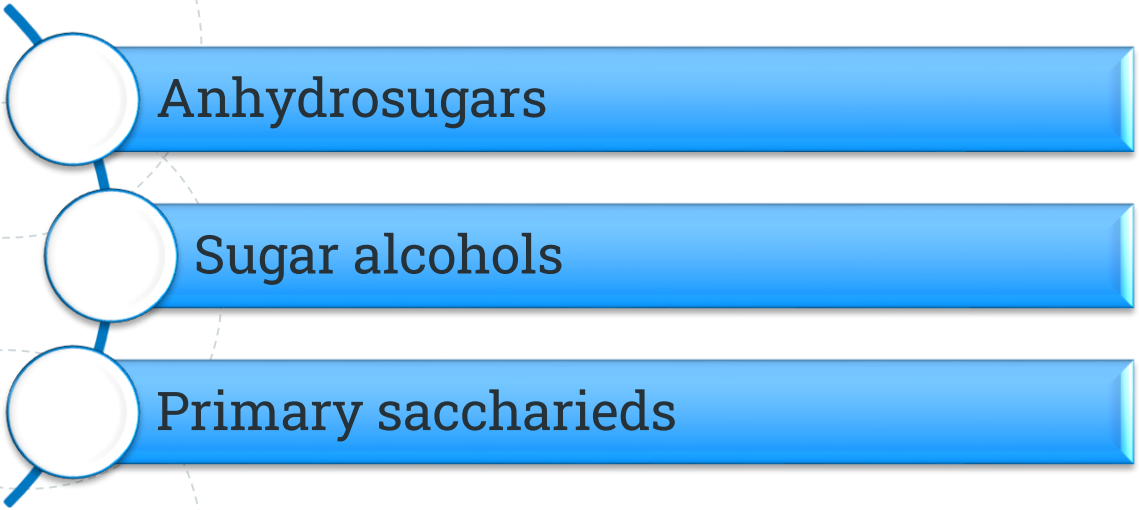
# Carbohydrates in the air

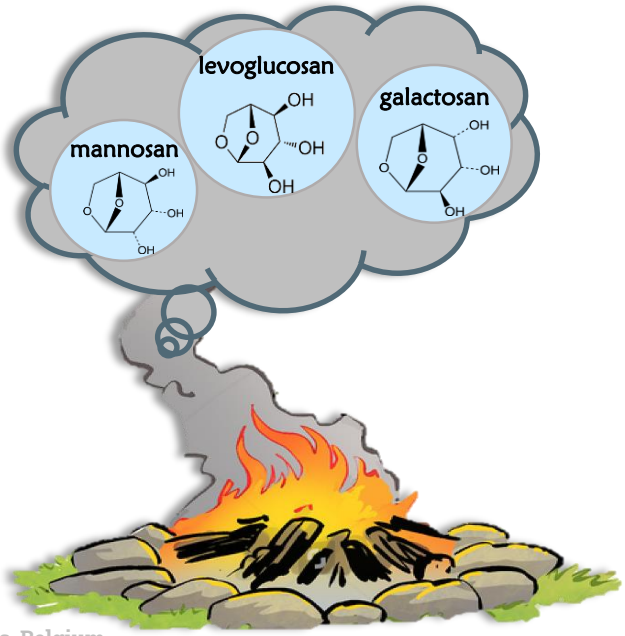


# Sources of carbohydrates in the air

## Anhydrosugars

- **Levoglucosan** (1,6-anhydro-β-D-glucopyranose)
- **Mannosan** (1,6-anhydro-β-D-mannopyranose)
- **Galactosan** (1,6-anhydro-β-D-galactopyranose)

- dehydrated derivates of monosaccharides
- large quantities by anthropogenic activities




- agricultural waste burning
- residential wood combustion
- forest fires

# Sources of carbohydrates in air

Sugar alcohols

- **Xylitol**
- **Erythritol**
- **Sorbitol**
- **Arabitol**
- **Mannitol**

- reduced sugars
- components of plants, spores, bacteria, lichens, and lower plants

- primary biological sources such as pollen, fungi, and bacteria
- breakdown products of polysaccharides
- direct volatilization of plant materials
- metabolic activity of various microorganisms
- thermal stripping of biomass burning

# Sources of carbohydrates in air

Primary saccharieds

- **Glucose**
- **Fructose**
- **Galactose**
- **Mannose**
- **Saccharose**

- continuous emissions from primary biological particles such as pollen, fungi, algae, growing leaves and decayed matter
- biomass burning (cellulose - glucose, hemicellulose - galactose, and mannose)
- biologically active soil dust

# Aim of the study

- to investigate the levels of carbohydrates in $PM_1$ particulate matter collected during wintertime in Zagreb City, Croatia
- to compare results with the analysis of carbohydrates in $PM_{10}$ particulate matter
- to determine the plausible source of carbohydrates
- to statistically compare carbohydrates and polycyclic aromatic hydrocarbons (PAHs) (Spearman correlation, Factor analysis, Principal Component Analysis (PCA))

# Experimental

## Sample collection

- fraction of $PM_1$ particulate matter
- urban background station
- sampling period: wintertime of 2020 (60 days)
- National Measuring Station for Continuous Air Quality Monitoring

# Experimental

## SAMPLE COLLECTION

Quartz filters Tissuquartz 2500QAT-UP
(Pall Life Sciences)
($A$ = 1,5 cm$^2$)

LVS3 Sven Leckel
( 55 m$^3$/day)

## SAMPLE TREATMENT

## GRAVIMETRY

Sample condicioning :
t = 24 h, 48 h
RH = 50 ± 5 %
T = 20 ± 1 °C

## SAMPLE PREPARATION

- ultrasonic extraction in ultra-pure water
- centrifugation

## SAMPLE ANALYSIS

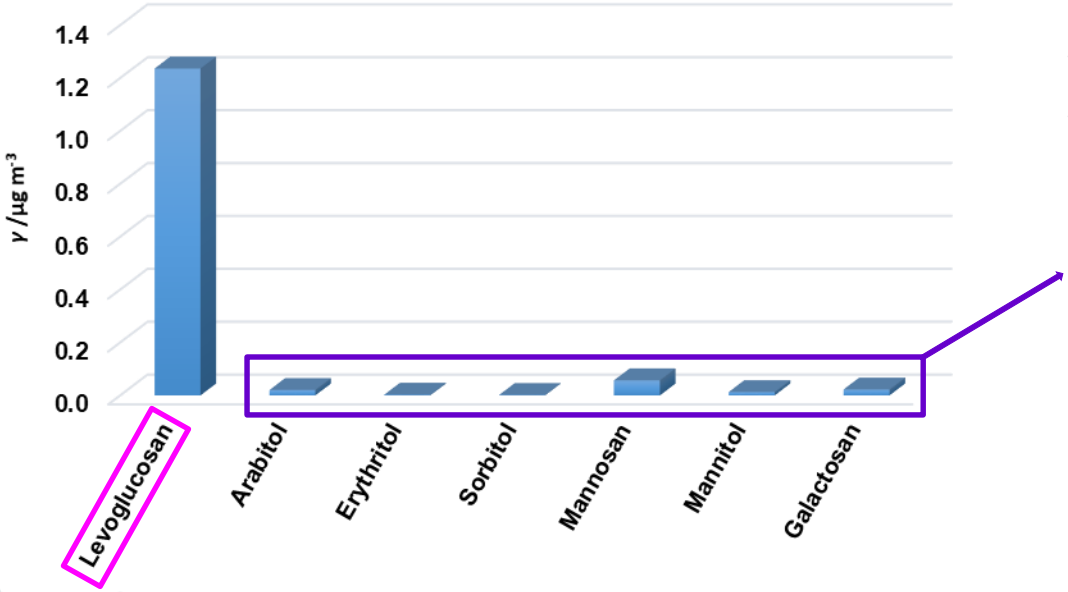
➢ **HIGH PERFORMANCE ANION-EXCHANGE CHROMATOGRAPHY WITH PULSED AMPEROMETRIC DETECTION**

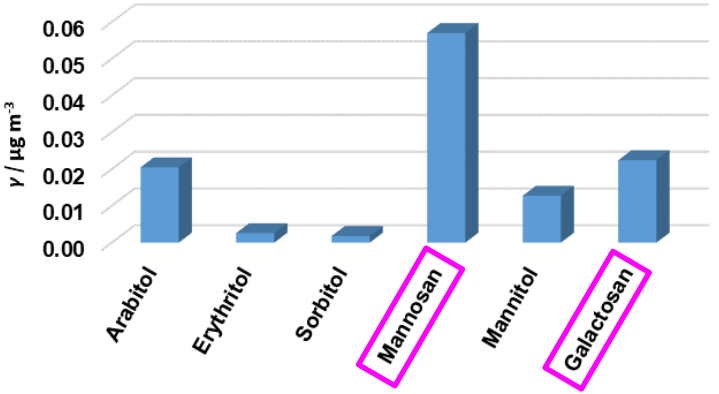
Eluent: NaOH, 0,4 ml/min

Separation column:
CarboPack MA1,
Thermo Fischer Scientific

# Results

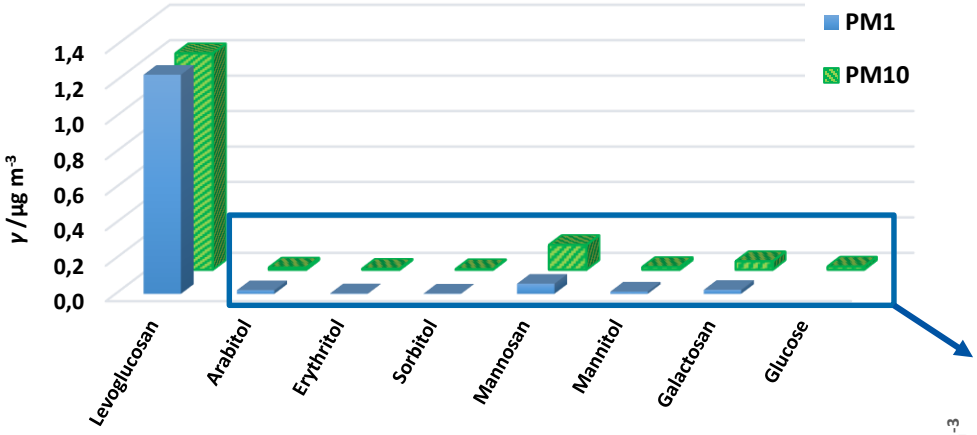
## Average mass concentrations of carbohydrates in $PM_1$ fraction

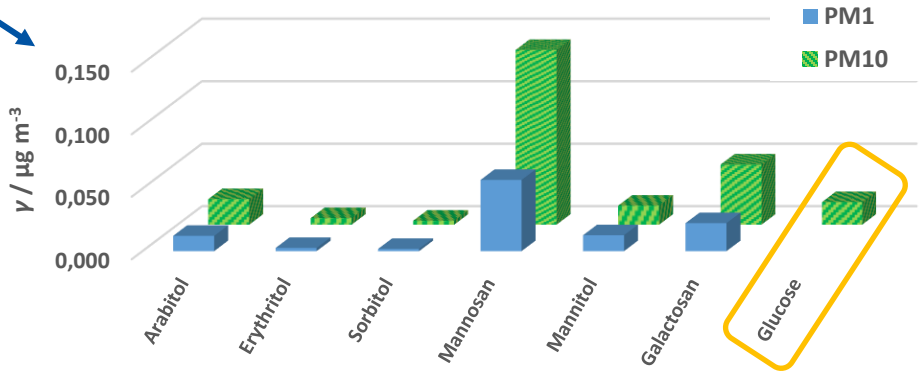



| γ / µg m$^{-3}$ | average | ± δ | max | min |
|---|---|---|---|---|
| Levoglucosan | 1.2361 | 0.9974 | 4.5505 | 0.128 |
| Arabitol | 0.0205 | 0.0128 | 0.0576 | 0.0011 |
| Erythritol | 0.0026 | 0.0015 | 0.0069 | 0.0001 |
| Sorbitol | 0.0018 | 0.0037 | 0.0113 | 0.0001 |
| Mannosan | 0.057 | 0.037 | 0.1603 | 0.0072 |
| Mannitol | 0.0128 | 0.0096 | 0.0360 | 0.003 |
| Galactosan | 0.0224 | 0.0210 | 0.0824 | 0.0009 |

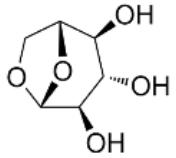
# Comparison of mass concentration in $PM_1$ and $PM_{10}$ fraction

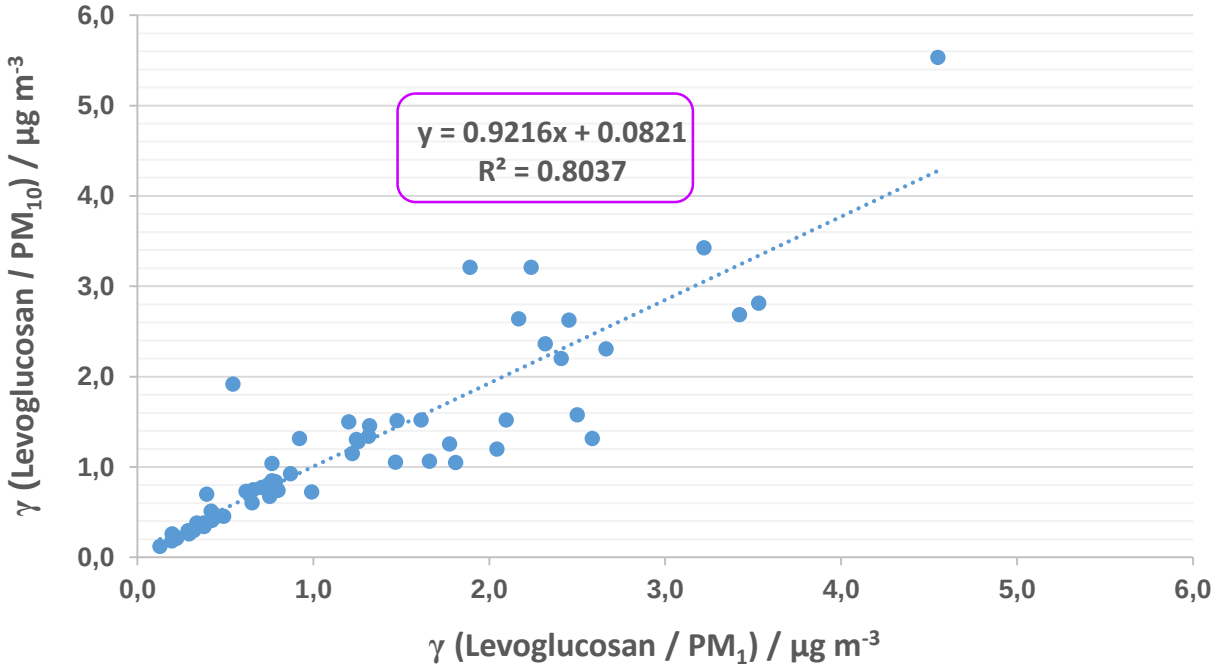



- ✓ similar mass concentration of levoglucosan in both fractions
- ✓ $PM_1 < PM_{10}$
- ✓ Glucose in $PM_{10}$

# Correlation of levoglucosan in $PM_1$ and $PM_{10}$ fraction




- **92.2 % of levoglucosan in $PM_{10}$ fraction is bounded to $PM_1$ fraction**

# Spearman correlation between carbohydrates and polycyclic aromatic hydrocarbons in $PM_1$ fraction

$p < 0.05$

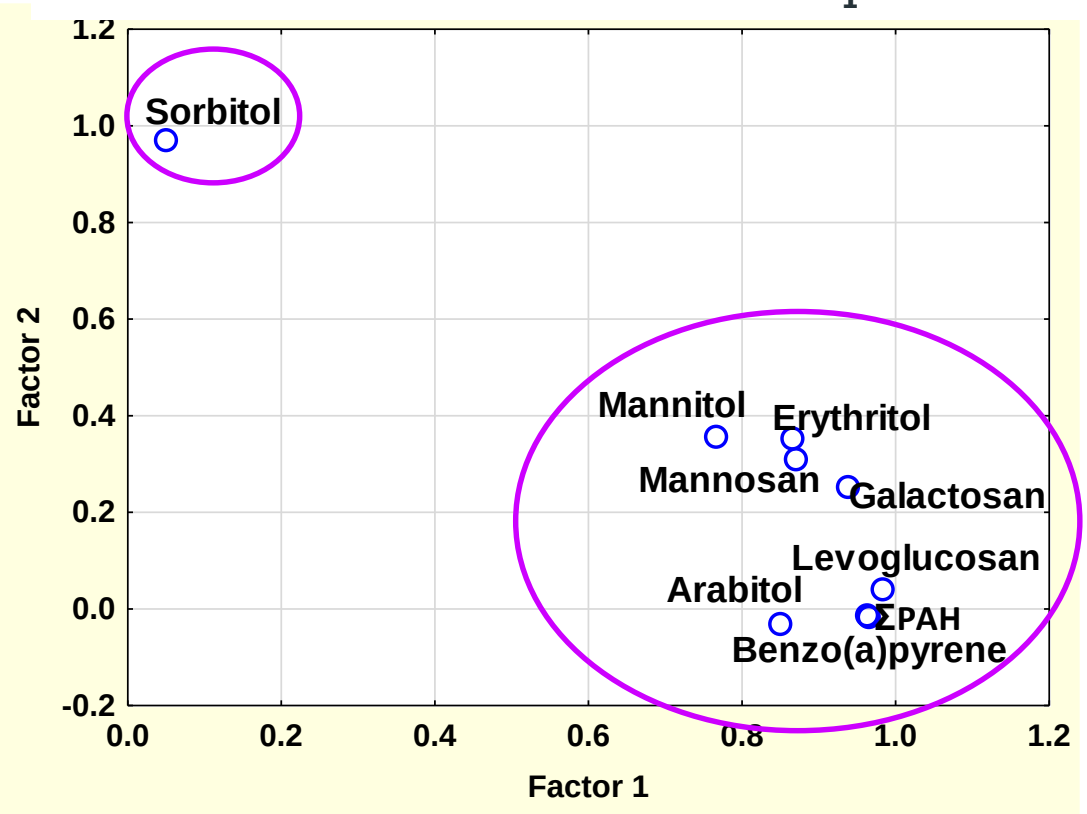
| | Levoglucosan | Arabitol | Erythritol | Sorbitol | Mannosan | Mannitol |
|---|---|---|---|---|---|---|
| Arabitol | 0.94 | | | | | |
| Erythritol | 0.82 | 0.82 | | | | |
| Sorbitol | 0.09 | 0.13 | 0.31 | | | |
| Mannosan | 0.91 | 0.85 | 0.87 | 0.23 | | |
| Mannitol | 0.72 | 0.70 | 0.76 | 0.29 | 0.74 | |
| Galactosan | 0.91 | 0.86 | 0.88 | 0.25 | 0.94 | 0.82 |

| | Levoglucosan | Arabitol | Erythritol | Sorbitol | Mannosan | Mannitol | Galactosan |
|---|---|---|---|---|---|---|---|
| Benzo[a]pyrene | 0.96 | 0.87 | 0.76 | 0.05 | 0.86 | 0.70 | 0.89 |
| ΣPAH | 0.96 | 0.87 | 0.75 | 0.05 | 0.86 | 0.70 | 0.88 |

- ✓ **carbohydrates** : very strong (ρ > 0.8) and strong (ρ > 0.6) correlation → except for sorbitol
- ✓ **PAHs and carbohydrates:** very strong (ρ > 0.8) and strong (ρ > 0.6) correlation → except for sorbitol

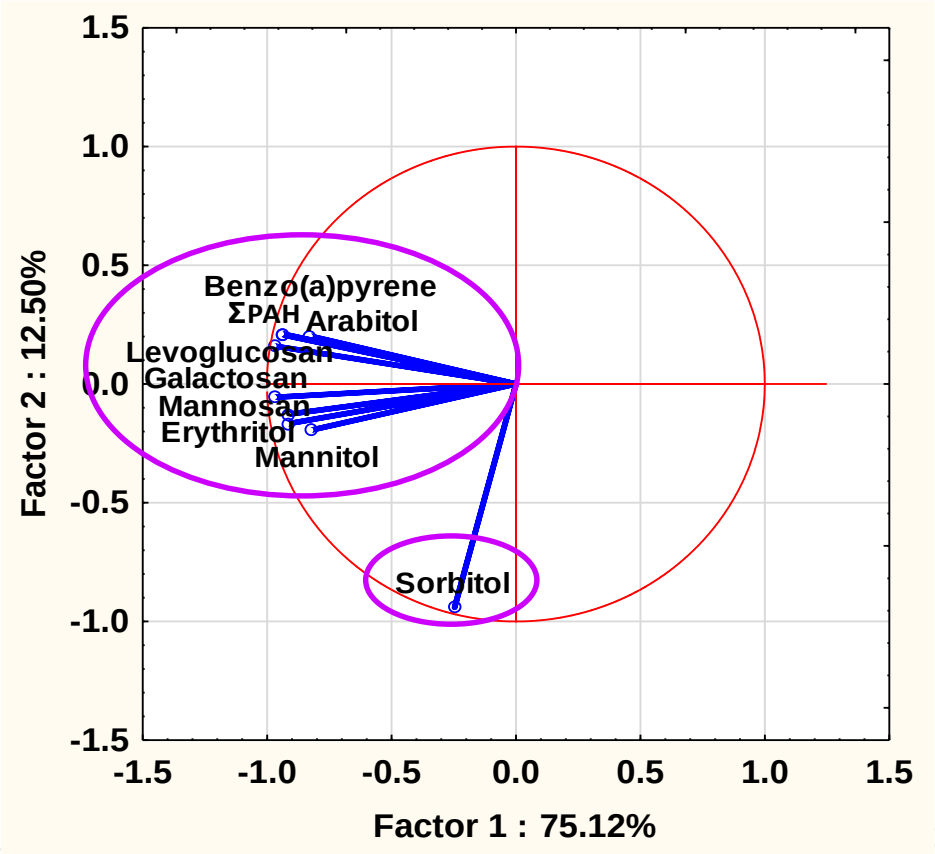
- ✓ **sorbitol:** insignificant correlation → different source ??

# Factor anaysis between carbohydrates and polycyclic aromatic hydrocarbons in $PM_1$ fraction




- ✓ confirmation of Spearman correlation
- ✓ separates two factors that may indicate two different pollution sources
- ✓ **Factor 1.** includes anhydrosugars, sugar alcohols, and polycyclic aromatic hydrocarbons
- ✓ **Factor 2.** sorbitol

# PCA anaysis between carbohydrates and polycyclic aromatic hydrocarbons in $PM_1$ fraction




- ✓ Confirmation of factor analysis
- ✓ two possible pollution sources
- ✓ **1. source** related to biomass burning

anhydrosugars, sugar alcohols, and polycyclic aromatic hydrocarbons

- residential heating during wintertime

- ✓ **2.source** probably related to biogenic acitivity (fungal spores, microorganisms)

# Conclusions

- ✓ During wintertime in $PM_1$ fraction of particulate matter sampled in the urban background station in Zagreb City, anhydrosugars and sugar alcohols are detected
- ✓ Most dominant compound in the $PM_1$ fraction of particulate matter was levoglucosan
- ✓ More than 90 % of levoglucosan in the $PM_{10}$ fraction is bound to the $PM_1$ fraction
- ✓ Spearman correlation showed a very strong and strong correlation among all of the detected carbohydrates and PAHs except for one sugar alcohol (sorbitol)
- ✓ Factor analysis confirmed the assumption of different sources of analyzed compounds; two factors were found
- ✓ PCA analysis confirmed the factor analysis; two pollution sources

    1. biomass burning from residential heating
    2. biogenic activity

- ✓ Further research will be focused on the seasonal variations and more input parameters (related analytes, meteorology) that would give more precise source identification of pollutants

# Thank you for your attention!