# DECONVOLUTION OF WATER CHEMISTRY CONCENTRATIONS INTO COMPONENTS: BACKGROUND, ANTHROPOGENIC, AND RESULTING FROM CHANGES IN METEOROLOGICAL PARAMETERS

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## THE AIM OF THE STUDY

**The purpose of this work is to develop a methodology that would allow separating the actual concentrations of water chemistry, not only, into the background, and anthropogenic components, but also assess the component resulting from changes in meteorological parameters**

## THEORETICAL BASIS

1. **Concentrations of individual indicators of the chemical composition of water (Y) – the sum of two independent components:**

- **concentrations due to natural factors (X1);**
- **concentrations due to human activity (X2);**

$$Y = X1 + X2$$

**2. The law of statistical distribution of actual concentrations $p_Y(y)$ is a convolution of the law of statistical distribution of concentrations natural origin $p_{X1}(x1)$, and the law of statistical distribution of concentrations anthropogenic origin $p_{X2}(y\text{-}x1)$:**

$$p_Y(y) = \int_{-\infty}^{+\infty} p_{X2}(y-x1)\, p_{X1}(x1)\,dx$$

**3. The law of statistical distribution of concentrations, natural origin $p_{X1}(x1)$, is a convolution of the law of statistical distribution of concentrations of natural background $p_{X4}(x4)$, and the law of statistical distribution of concentrations caused by climate change $p_{X3}(x1\text{-}x4)$:**

$$p_{X1}(x1) = \int_{-\infty}^{+\infty} p_{X3}(x1-x4)\, p_{X4}(x4)\,dx$$

## ALGORITHM OF STOCHASTIC EVALUATION

**Identification of the laws of statistical distributions of concentrations: model Generalized normal distribution: version 1**

$$p(x) = \frac{\alpha}{2\lambda\sigma\Gamma(1/\alpha)} \exp\left(-\left|\frac{x-\mu}{\lambda\sigma}\right|^{\alpha}\right) \quad \lambda = \sqrt{\frac{\Gamma(1/\alpha)}{\Gamma(3/\alpha)}} \quad \varepsilon = \frac{\Gamma(1/\alpha)\Gamma(5/\alpha)}{(\Gamma(3/\alpha))^2}$$

**σ - the standard deviation, μ - the center of distribution, α - the shape parameter, ε – excess, Γ(z) - gamma function, if α = 2, then it is the Gaussian distribution.**

**Calculation of limit concentrations of climatic norm (natural background) and limit concentrations of natural origin (actual background):**

**1) the concentrations of a number of observations are ranked; 2) calculate the selection values of excess (ε) and eccentricity (s); 3) unbiased estimates G1 and G2 and standard deviations SG1 and SG2 are calculated; 4) if n> 50, then the hypothesis of the limit of concentrations of the climatic norm is accepted with a reliability of 0.95, provided:**

$$|G_1| \le 3S_{G1} \qquad |G_2| \le 3S_{G2}$$

**5) if n> 50, then the hypothesis of the limit of concentrations of natural origin is accepted with a reliability of 0.99, provided:**

$$|G_1| \le 5S_{G1} \qquad |G_2| \le 5S_{G2}$$

**Identification of the laws of statistical distribution of concentrations of anthropogenic origin $p_{X2}$ and statistical distribution of concentrations due to climate change $p_{X3}$**

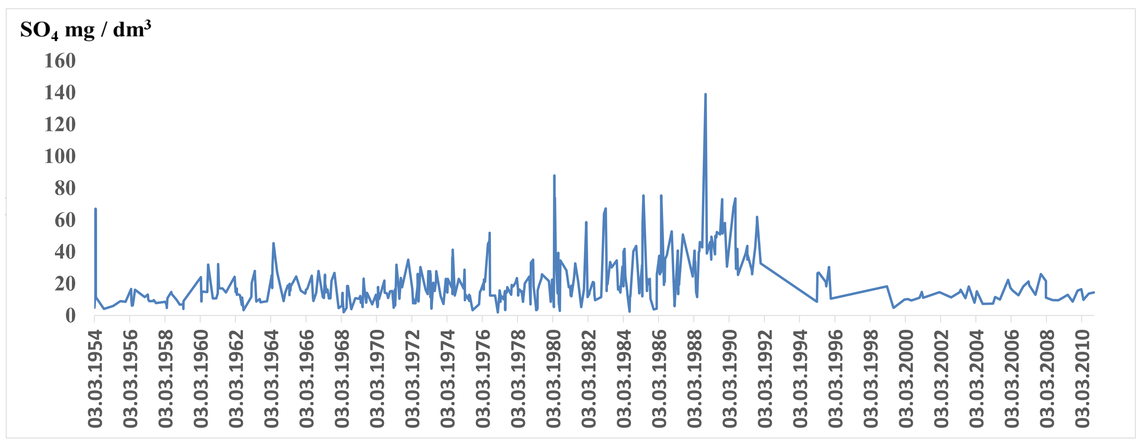
$$p_{X2} = \frac{\alpha}{2\lambda\sigma_{X2}\Gamma(1/\alpha)} \exp\left(-\left|\frac{x_{X2}-\mu_{X2}}{\lambda\sigma_{X2}}\right|^{\alpha}\right) \qquad p_{X3} = \frac{\alpha}{2\lambda\sigma_{X2}\Gamma(1/\alpha)} \exp\left(-\left|\frac{x_{X3}-\mu_{X3}}{\lambda\sigma_{X3}}\right|^{\alpha}\right)$$

$$\mu_{X2} = \mu_Y - \mu_{X1} \qquad \sigma_{X2}^2 = \sigma_Y^2 - \sigma_{X1}^2 \qquad \mu_{X3} = \mu_{X1} - \mu_{X4} \qquad \sigma_{X3}^2 = \sigma_{X1}^2 - \sigma_{X4}^2$$

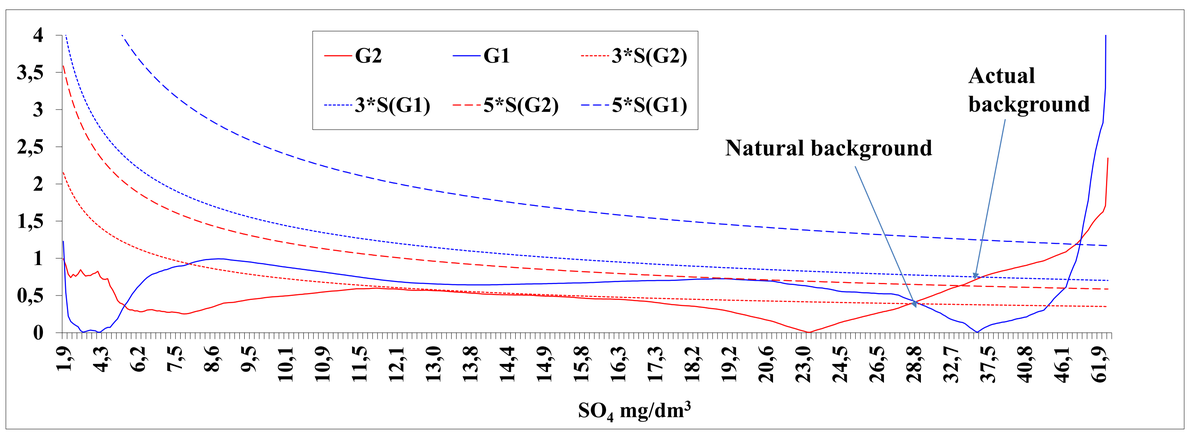
## METHOD

## DECONVOLUTION OF CONCENTRATIONS OF SULFATE IONS IN THE HOLOVESNYA RIVER INTO COMPONENTS: BACKGROUND, ANTHROPOGENIC, AND CONCENTRATIONS FROM CLIMATE CHANGE

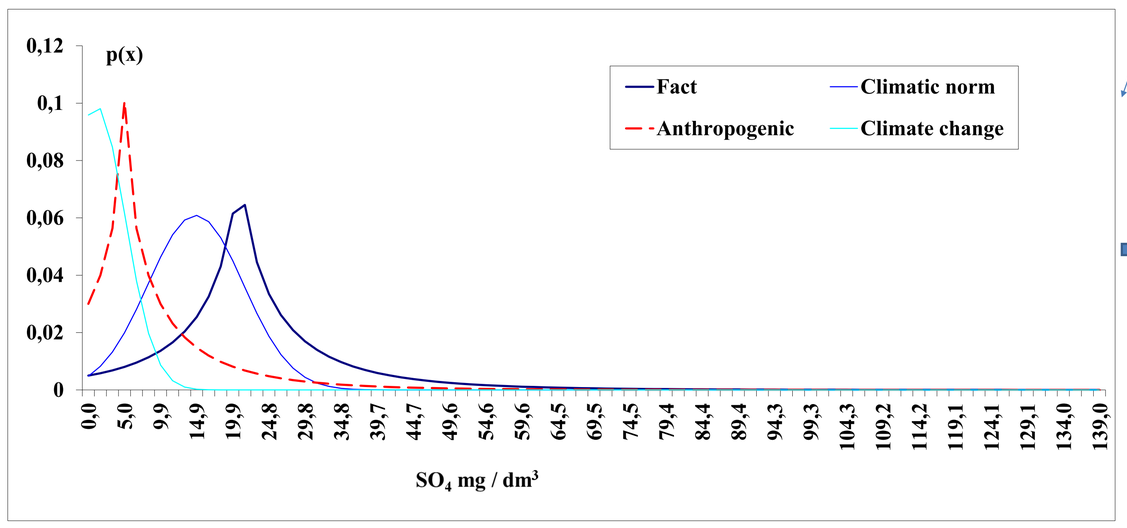
### ACTUAL SULFATE IONS CONCENTRATIONS for 1954-2010 (Golovesnya River, Pokoshychi village)




### DETERMINATION OF LIMIT SULFATE IONS CONCENTRATIONS OF CLIMATIC NORM (NATURAL BACKGROUND) AND LIMIT CONCENTRATIONS OF NATURAL ORIGIN (ACTUAL BACKGROUND) (Golovesnya River )

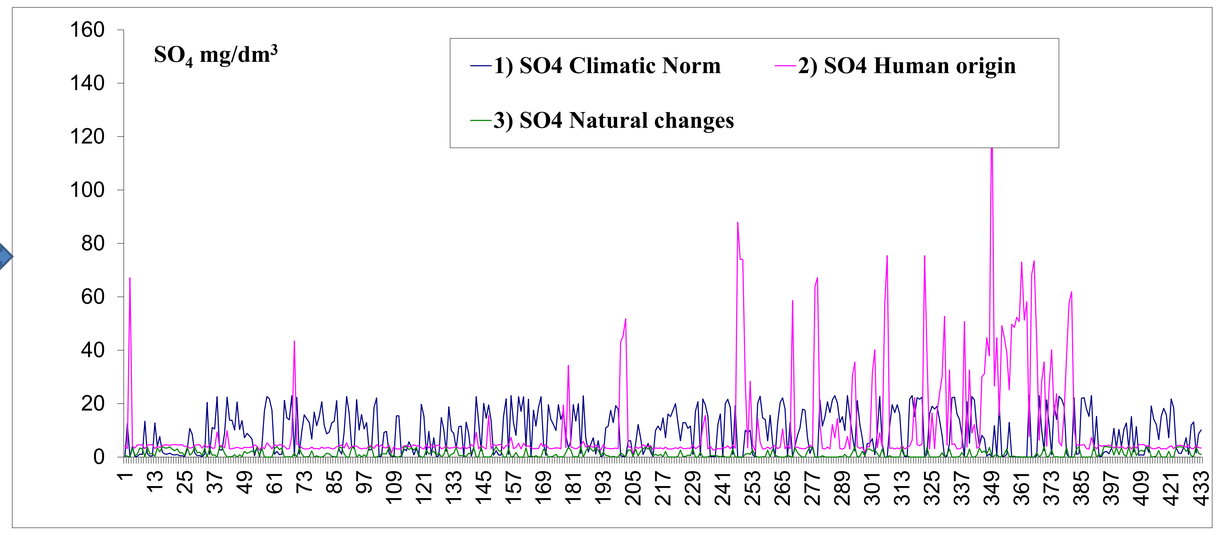



### LAWS OF STATISTICAL DISTRIBUTIONS OF COMPONENTS OF ACTUAL SULFATE IONS CONCENTRATIONS (Golovesnya River)




## RESULTS

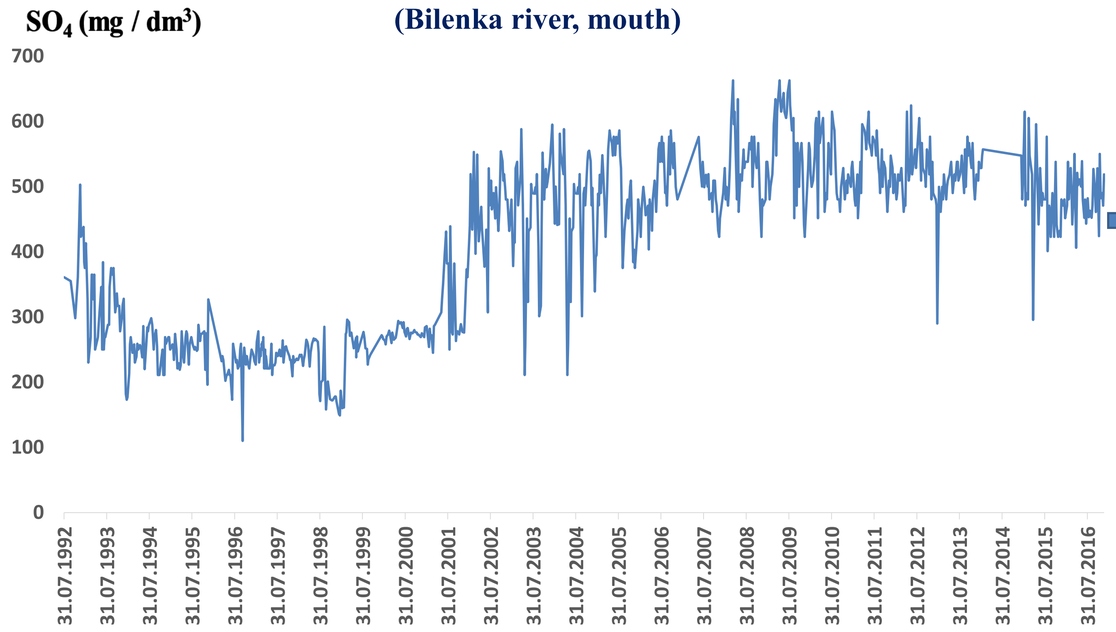
### COMPONENTS OF ACTUAL SULFATE IONS CONCENTRATIONS (Golovesnya River)




## METHOD

## DECONVOLUTION OF CONCENTRATIONS OF SULFATE IONS IN THE BILENKA RIVER INTO COMPONENTS: BACKGROUND, ANTHROPOGENIC, AND CONCENTRATIONS FROM CLIMATE CHANGE

### ACTUAL SULFATE IONS CONCENTRATIONS for 1992-2016 (Bilenka river, mouth)




## RESULTS

### THE AVERADGE VALUES OF THE COMPONENTS OF THE STATISTICAL DISTRIBUTIONS SULFATE IONS OF THE RIVER BILENKA (0.5 km above the mouth) at 95% confidence intervals of the average

| Evaluation periods | Actual background (natural background + climate change) | Natural background (reference state, climatic norm) | Anthropogenic | Climate change |
|---|---|---|---|---|
| 1992-1996 | 266,49 ±8,70 | 261,56 ± 7,73 | 2,96 ± 2,00 | 4,94 ± 4,01 |
| 1997-2001 | 253,65 ±6,30 | 252,63 ± 5,99 | 0,00 ± 0,00 | 1,02 ± 1,00 |
| 2002-2006 | 337,00 ±8,64 | 252,63 ± 5,99 | 138,51 ± 6,33 | 84,37 ± 6,12 |
| 2007-2011 | 469,13 ±3,10 | 252,63 ± 5,99 | 63,96 ± 7,81 | 216,50 ± 5,54 |
| 2012-2016 | 459,32 ±3,64 | 252,63 ± 5,99 | 46,79 ± 5,95 | 206,69 ± 5,58 |