GENASIS: On-line data browser for environmental monitoring and associated information systems

Jiří Jarkovský, Ladislav Dušek, Miroslav Kubásek, Jana Klánová, Richard Hůlek, Jakub Gregor, Kateřina Šebková, Jana Borůvková, Jiří Hřebíček, Ivan Holoubek

www.genasis.cz

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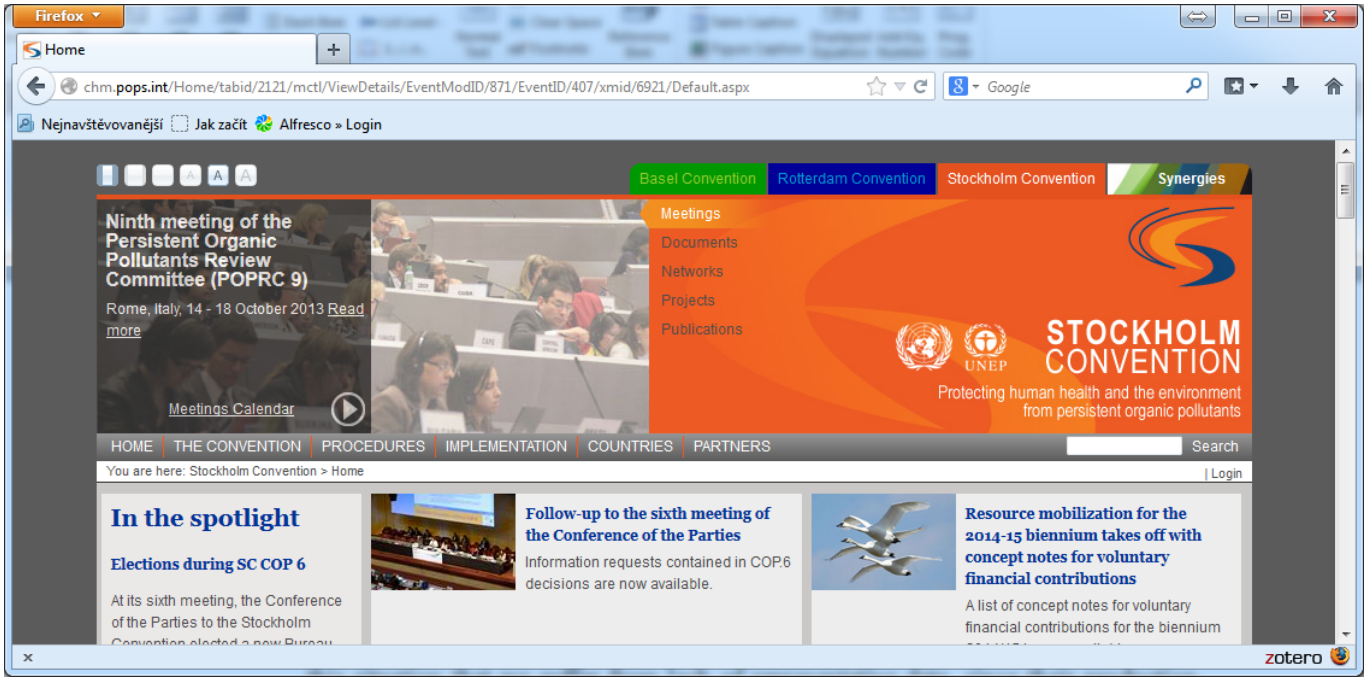
Brno, Czech Republic

Introduction

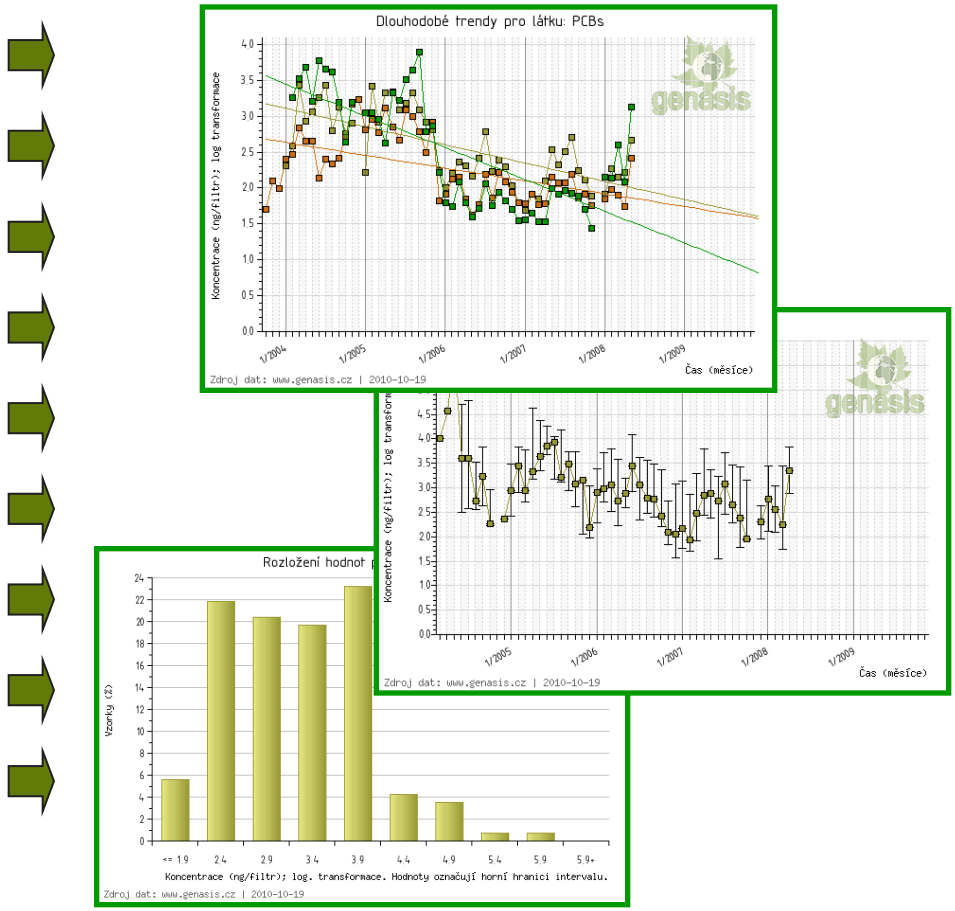
- Current environmental research is producing large quantities of data from many monitoring programmes
- Decisions based on these data have deep impact on the society – nice example are POPs and measures taken under the Stockholm convention
  - POPs are characterized by their acute and chronic toxicity, carcinogenity, immunotoxicity, they are persistent and capable of long-range transport and bioaccumulation in animal tissues
- But mostly there is not standardized accessibility of these environmental data !
- **We need comprehensive IT infrastructure which meets these tasks**



Available data and information

„Data rich – information poor“ …… never more !

Ukázka uspořádaného datového souboru										
cislo	stadium	vek	tran1_3	tran1_4	tran1_5	tran1_6	alb_pbsct	ldh_vstup	sternum	typ_myel
1	3	33	104.36	23.24	104.3	57.77	33	6.02	0.4	IgG
2	3	33	184.88	7.84	105.5	13.82	26	4.01	30	IgG
3	1	34	123.41	9.8	73.3	13.05	32	3.73	45.2	IgG
4	2	43	52.17	6.66	18.03	17.19	42	4.67	40.8	IgG
5	1	45	8.22	2.2	8.22		32	8.25	2	B-J
6	3	46	403.08		13.31		29.7	7.17	38.8	IgA
7	2	49		4.5		2.25	34	4.99	6.4	IgG
8	2	50	33.13	9.64	33.13		35	3.99	14	IgG
9	3	52	257.08	12.05	85.1	3.24	39	12.14	12.2	IgG
10	2	53	78.33	11.34	47.54	7.77	39	5.3	13.6	IgG
11	3	53	61.43	4.67	14	3.72	32	4.51	49.2	B-J
12	3	53	135.8	6.7	135.8	59.3	38		26	IgG
13	3	54	129.16	13.33	92.6	38.24	32	4.18	20	IgG
14	3	54	66.89	6.74	33.58	17.3	38	8.44	7.2	B-J
15	3	54	82.86	4.32	18.9	16.4	37	3.6	50	B-J
16	3	55	71.37	6.34	23.91	5.34	43	8.75	27	B-J
17	3	60	14.6	0.9	14.6	11.88	44	5.35	7.5	IgG
18	3	61	94.07	5.62	94.07	1.51	33	4.29	6.4	B-J
19	3	62	86.84	7.53	32.13	2.61	29	4.55	34	IgA



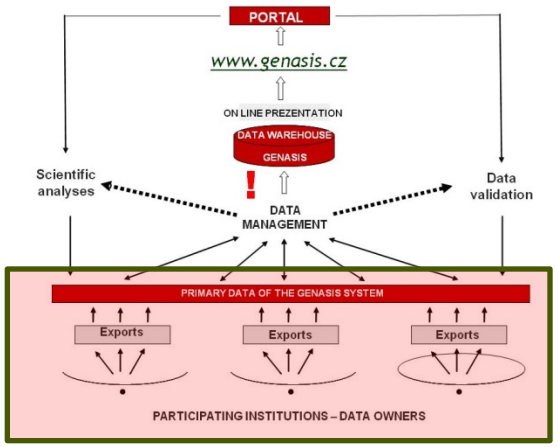
- How to make accessible monitoring outcomes, typically hundreds of separated files, with thousands possible views and statistics ?

Our proposal and solution:

GENASIS data browser (www.genasis.cz):

Example of monitoring of POPs concentrations

GENASIS: implemented principles

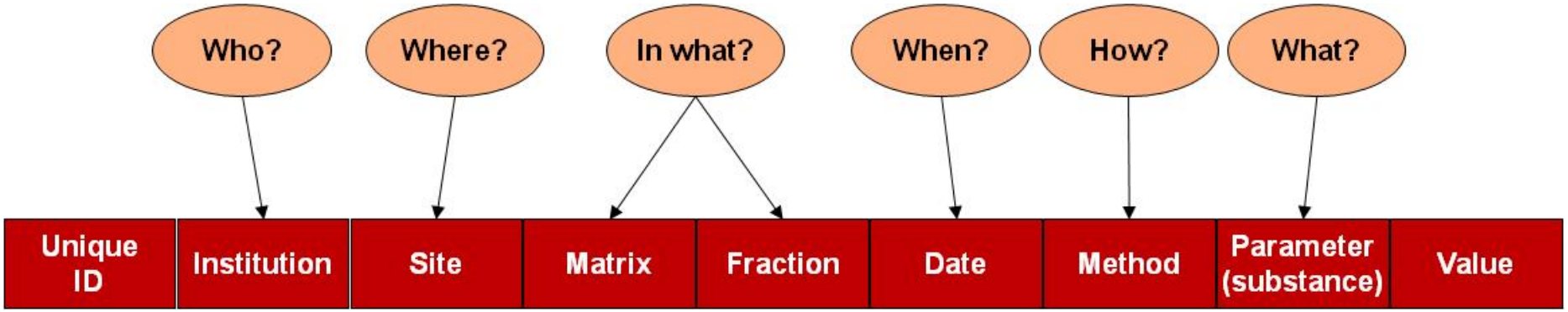


Principle 1.

Contract-based participation of partners and safety management

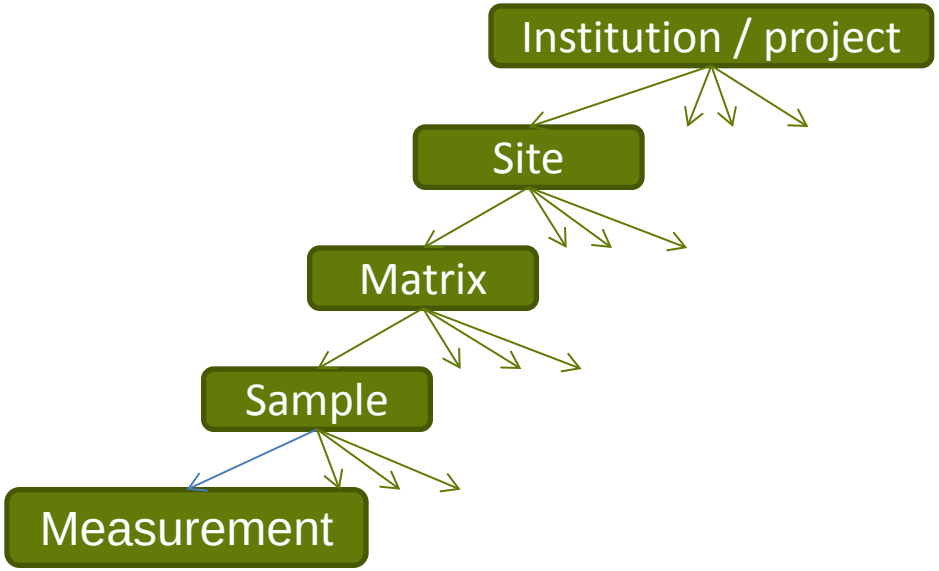
Principle 2.

Strictly defined and standardized minimum data record

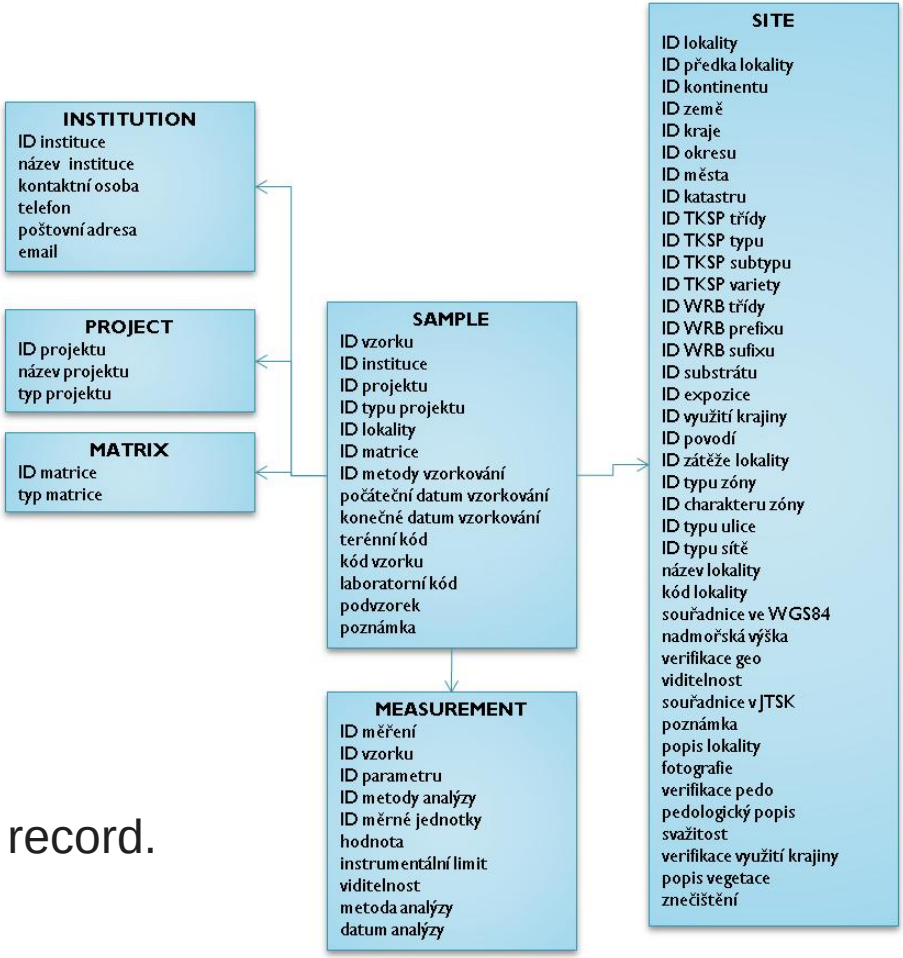


Principle 3.

Multi-layer, hierarchically structured data model



- time
- parameter
- method
- value
- unit

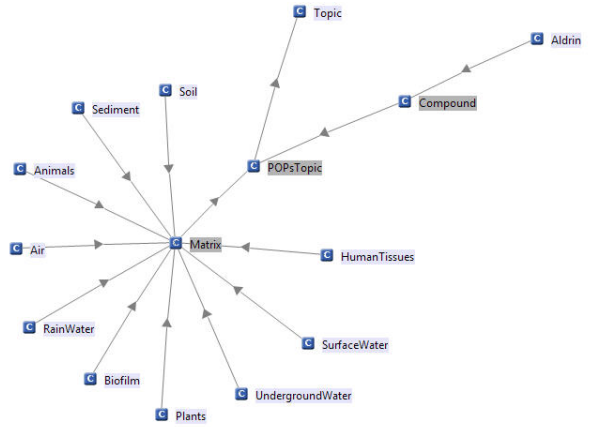


Each level has its own defined minimum data record.

Principle 4.

Well defined ontology and conceptual data model of a repository

- **I. NOMENCLATURE**
  - Key nomenclature system
  - Nomenclature subsystem(s)
- **II. CLASSIFICATION ATTRIBUTES**
  - Carcinogenicity
    Classifier: Yes / No / Suspection
  - Reference concentration values
    Classifier: > / = / <
- **III. INFORMATION SOURCE IDENTIFIERS**
  - Type of project
  - Problem studied
- **IV. OBLIGATORY DESCRIPTORS**
  - Matrix / method
  - Time & site specification
  - Concentration - units



Conceptual model enhancing accessibility of data from cancer–related environmental risk assessment studies

Ladislav Dušek[1,2], Jiří Hřebíček[1], Miroslav Kubásek[1], Jiří Jarkovský[1], Jiří Kalina[1], Roman Baroš[2], Zdeňka Bednářová[2], Jana Klánová[2], Ivan Holoubek[2]

[1] Institute of Biostatistics

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kalina@iba.muni.
klanova

Abstract. This pape
the discovery, integ
risk studies. Persiste
their persistence, bio
cancer risk is primar
encompassing a wid
to national cancer re
working with charac
nomenclature classe
defining classes. Th
multidimensional se
and precision. It rep
properties, as well a
weight the result in

GENASIS Information System: a Global Environmental Assessment of Persistent Organic Pollutants

Ivan Holoubek[1], Ladislav Dušek[1,2], Jana Klánová[1], Miroslav Kubásek[2], Jiří Jarkovský[2], Roman Baroš[1], Klára Kubošová[1], Zdeňka Bednářová[1], Richard Hůlek[2], Jiří Hřebíček[2]

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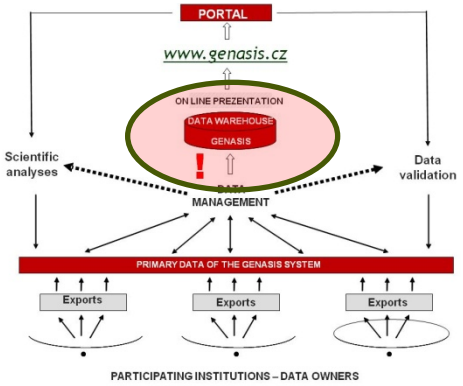
[2] Institute for Biostatistics and Analyses, Masaryk University, Kamenice 126/3, 625 00 Brno, Czech Republic,

Abstract. Global ENvironmental ASsessment and Information System (GENASIS) is a tool developed by expert teams of the Research Centre for Toxic Compounds in the Environment (RECETOX) and the Institute for Biostatistics and Analyses (IBA) of the Masaryk University in Brno. The aim of GENASIS is to compile validated data on persistent organic pollutants, including their properties, sources, long-term levels, life times, transport mechanisms, effects and risks, scattered throughout various institutions and

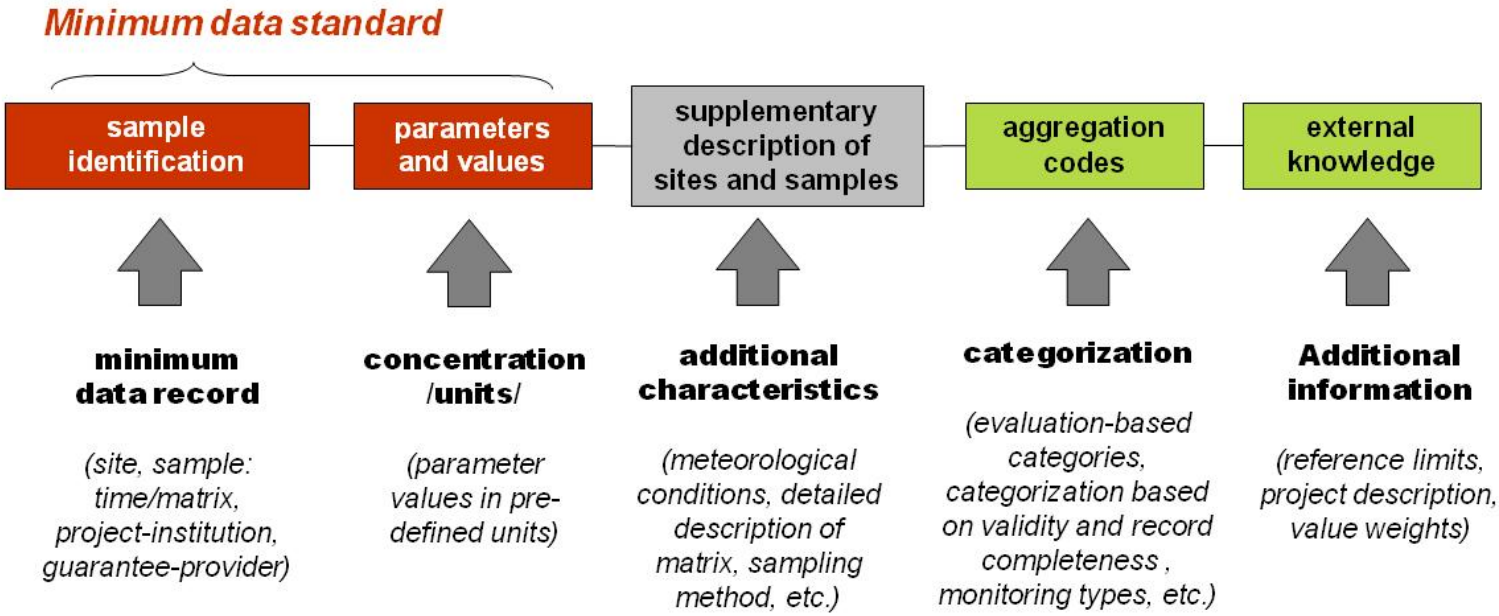
Principle 5.

Extended data model in data warehouse and metadata management



Data warehouse operator: pre-processing of entering data:

1. Standardization of items, parameters in records
2. Enrichment of data model by key descriptors (classifiers)
3. Necessary data transformation



Statistical processing of POPs data should solve the following tasks:

1. **Statistical summary = baseline summary statistics** of data and their variability

2. **Variability / uncertainty analysis,** description of the variability in the data

3. **Trend analysis** – Identification of variability sources (random processes, seasonality, trend) and their processing prior to trend quantification

   -> detection: nonparametric detection of trends

   -> quantification: stochastic linear and nonlinear models for trend detection

Simplicity and robustness are the main principles when processing the POPs records.

Non-parametric tests and summary statistics with no or negligible assumptions for the distribution patterns are highly recommended:

- Median estimates supplied with 5^{th}-95^{th} percentile range and geometric mean estimated on the basis of log-transformed data with corresponding 95% confidence interval are recommended for the summary statistics.
- Spearman's rank correlation coefficient is recommended for correlation analysis.
- Mann-Kendall and Daniel's test are recommended for trend detection.

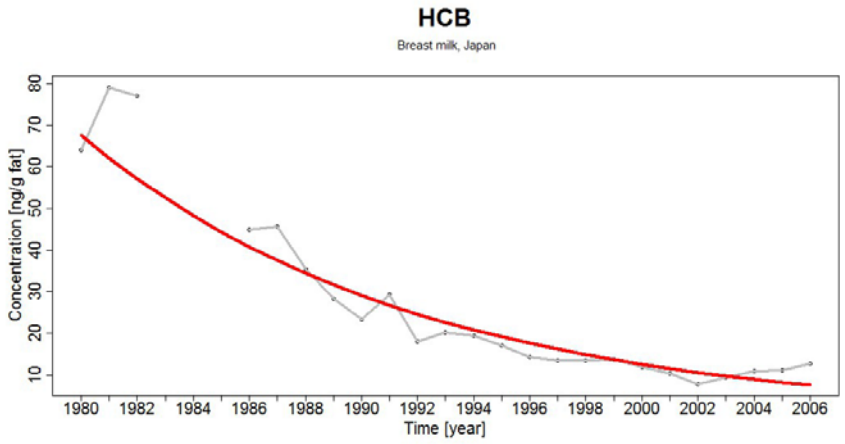
Trend detection and quantification

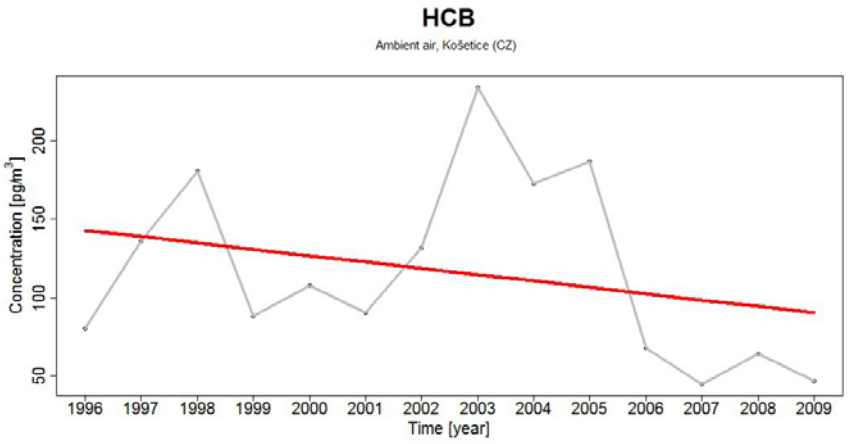
Short time series

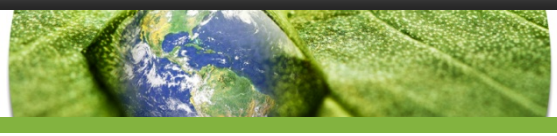
Delta difference between start-end of time series

Long time series

- Nonparametric trend identification (Daniel, Mann-Kendall test)
- Trend quantification using regression models (linear or exponential)
- Delta difference between start-end of time series as supplementary descriptive statistics



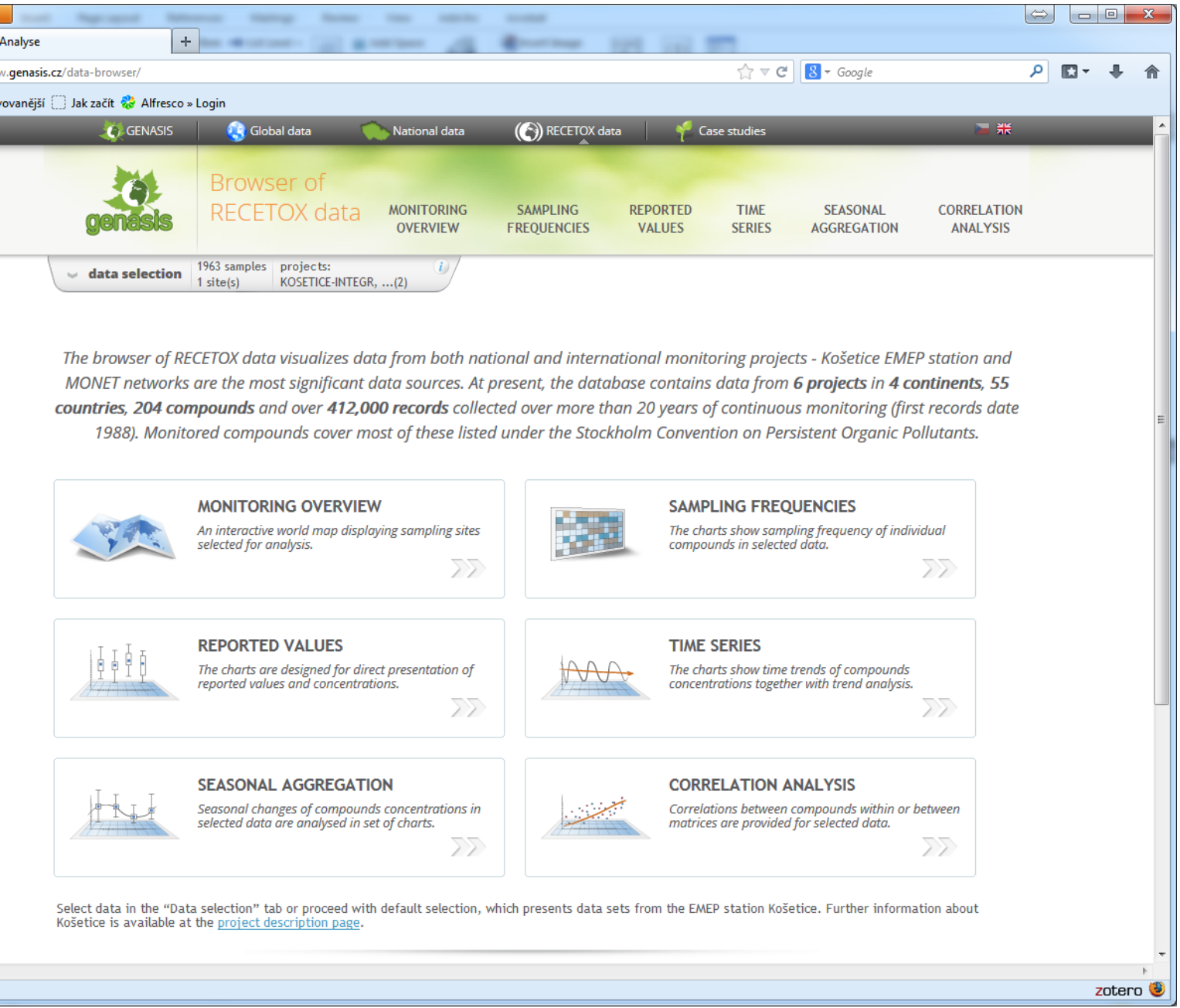




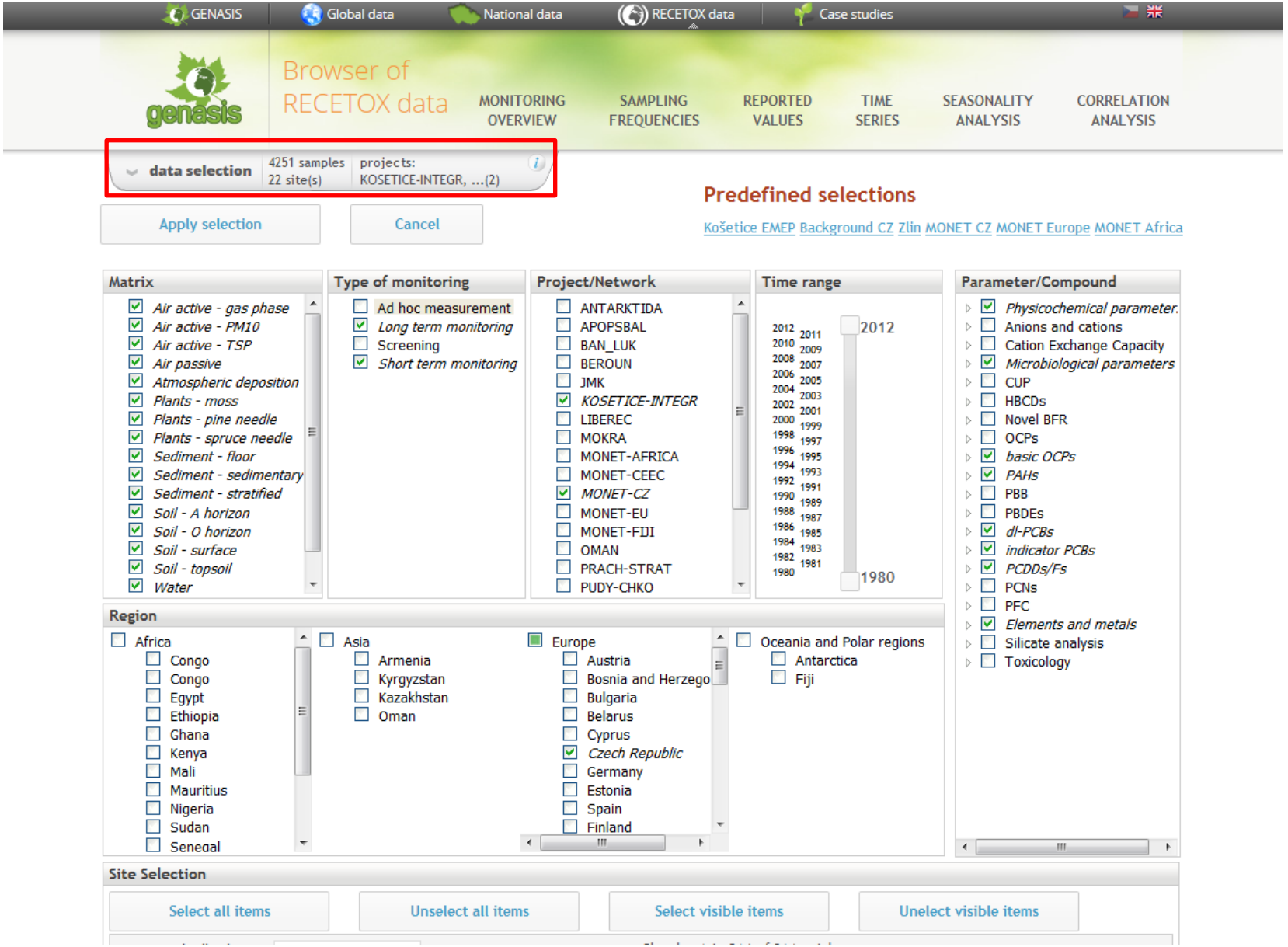
The R statistical environment was chosen as a tool for GMP data analysis and visualisation.

- R could be run as a desktop or server application (as a part of a web system), extensive library of statistical functions is used for environmental data evaluation on IBA;
- the environment disposes of a huge pool of ready-made packages for almost all applications in the field of environmental statistics;
- an open source character and recurrent form of R environment allows an easy creation of new functions and packages for sharing experiences;
- R allows to use proven functions and procedures avoiding ambiguities in the data analysis and save a substantial part of the development capacity used for validation and correction processes;
- R algorithms are optimized for quick performance in the case of the web implementation.

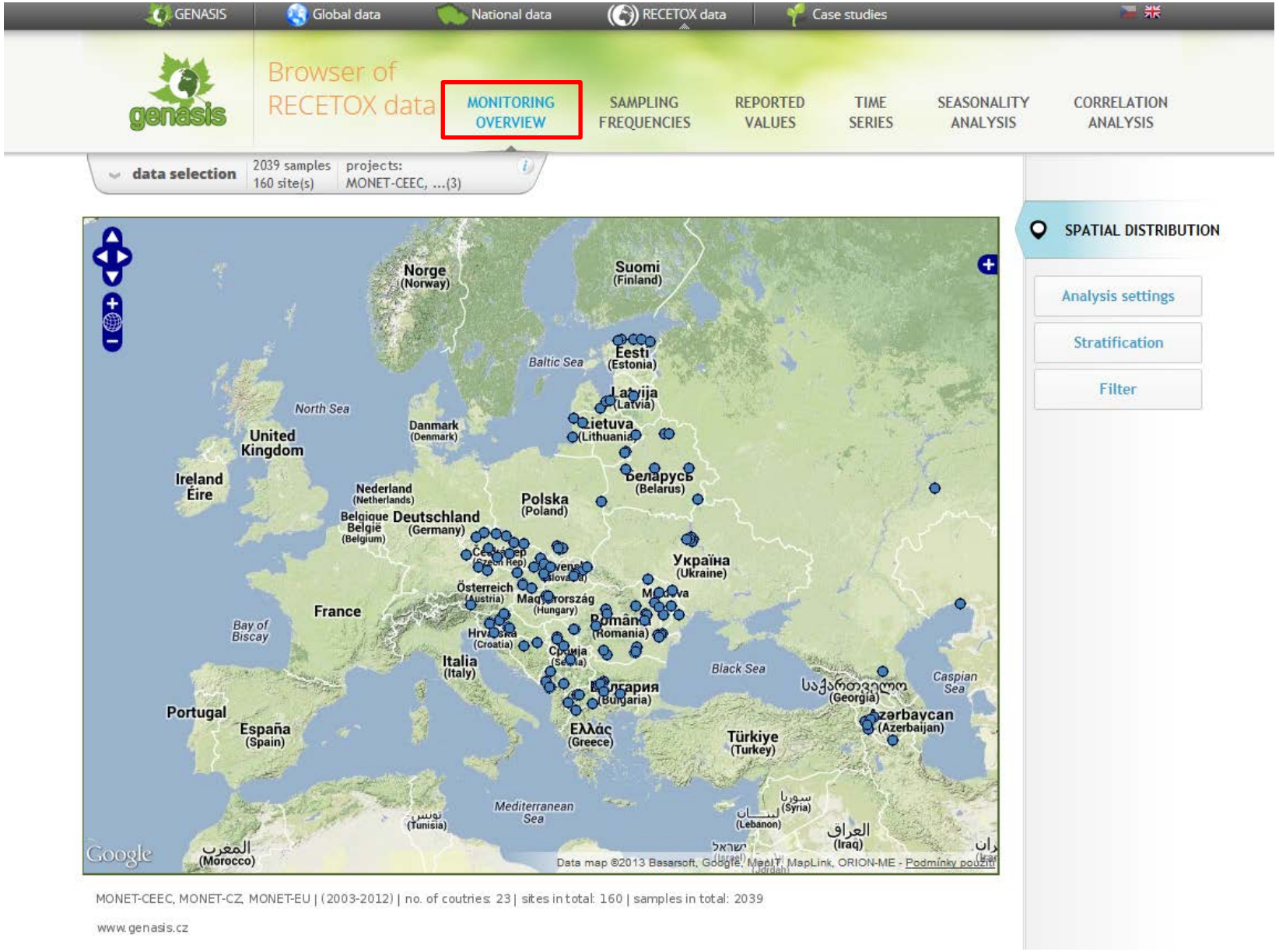
GENASIS v. 3.9 – system functions



Data selection



Overview of selected sites



MONET-CEEC, MONET-CZ, MONET-EU | (2003-2012) | no. of coutries: 23 | sites in total: 160 | samples in total: 2039

www.genasis.cz

Overview of sampling frequencies

GENASIS | Global data | National data | RECETOX data | Case studies

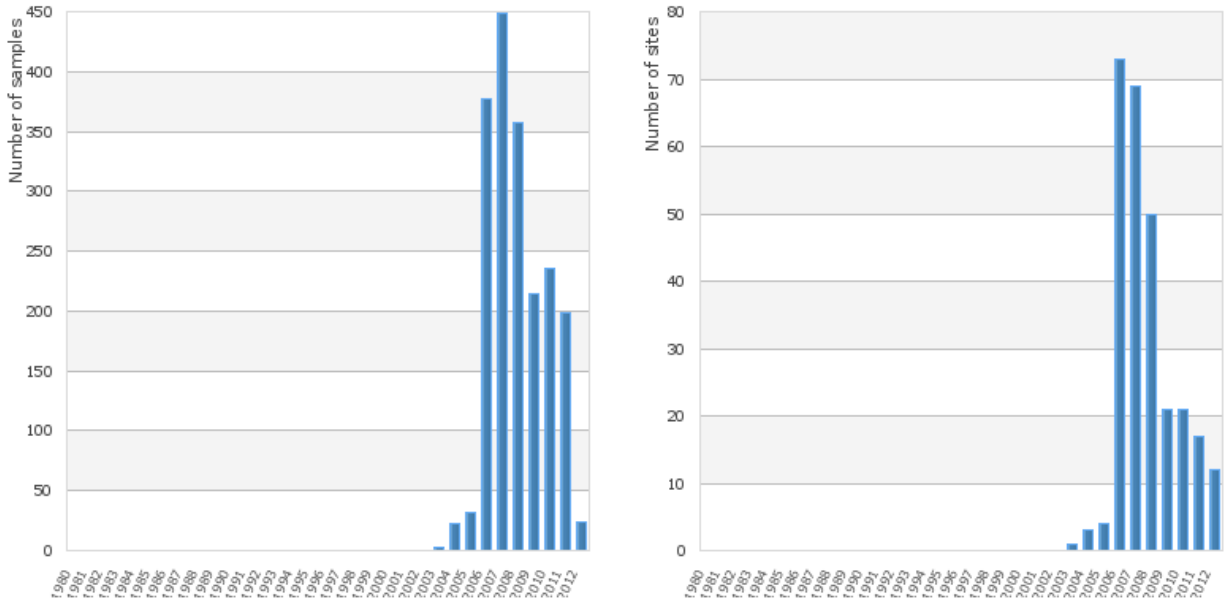
genasis

Browser of RECETOX data

MONITORING OVERVIEW | SAMPLING FREQUENCIES | REPORTED VALUES | TIME SERIES | SEASONALITY ANALYSIS | CORRELATION ANALYSIS

data selection | 2039 samples, 160 site(s) | projects: MONET-CEEC, ...(3)

Alpha-HCH (air passive) - sampling frequency



MONET-CEEC, MONET-CZ, MONET-EU | (2003-2012) | no. of coutries: 23 | sites in total: 160 | samples in total: 1914

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SINGLE COMPOUND

SINGLE COMPOUND BY SITES

MULTIPLE COMPOUNDS

Compound/Parameter

Analysis settings

Stratification

Filter

download data

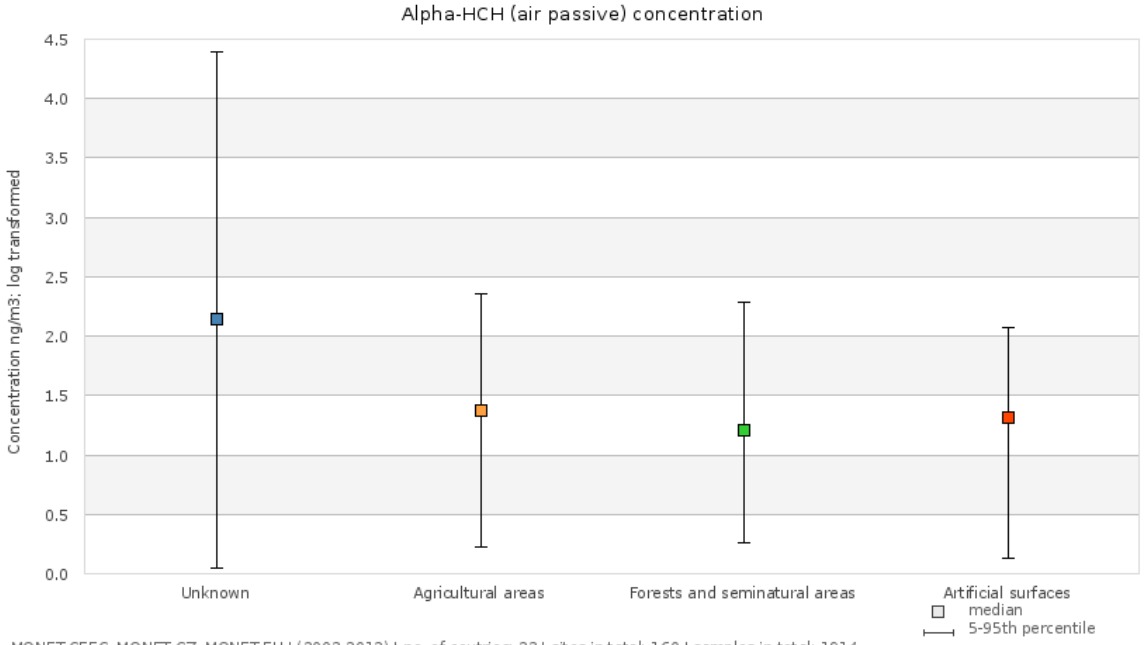
Visualisation of measured concentrations

GENASIS | Global data | National data | RECETOX data | Case studies

Browser of RECETOX data

MONITORING OVERVIEW | SAMPLING FREQUENCIES | REPORTED VALUES | TIME SERIES | SEASONALITY ANALYSIS | CORRELATION ANALYSIS

data selection | 2039 samples, 160 site(s) | projects: MONET-CEEC, ...(3)



MONET-CEEC, MONET-CZ, MONET-EU | (2003-2012) | no. of coutries: 23 | sites in total: 160 | samples in total: 1914
Base: samples | Stratified by: LanduseType
www.genasis.cz

ng/m³	Unknown	Agricultural areas	Forests and seminatural areas	Artificial surfaces
Number of samples (sites)	750 (145)	577 (7)	495 (7)	92 (1)
Median (5th - 95th percentile)	7.51 (0.05 - 80.04)	2.97 (0.25 - 9.58)	2.36 (0.30 - 8.85)	2.72 (0.14 - 6.97)
Median (25th - 75th percentile)	7.51 (3.25 - 19.54)	2.97 (1.60 - 5.02)	2.36 (1.25 - 4.18)	2.72 (1.49 - 3.99)
Minimum - maximum	0.05 - 2125.14	0.05 - 256.46	0.05 - 47.92	0.05 - 12.38

HISTOGRAM

BOX & WHISKER PLOT

BOX & WHISKER PLOT BY SITES

Compound/Parameter

Analysis settings

Stratification

Filter

Stratified by

LanduseType

- Unknown
  sites: 145 | samples: 750
- Agricultural areas
  sites: 7 | samples: 577
- Forests and seminatural areas
  sites: 7 | samples: 495
- Artificial surfaces
  sites: 1 | samples: 92

Time series and trend analysis

GENASIS | Global data | National data | RECETOX data | Case studies

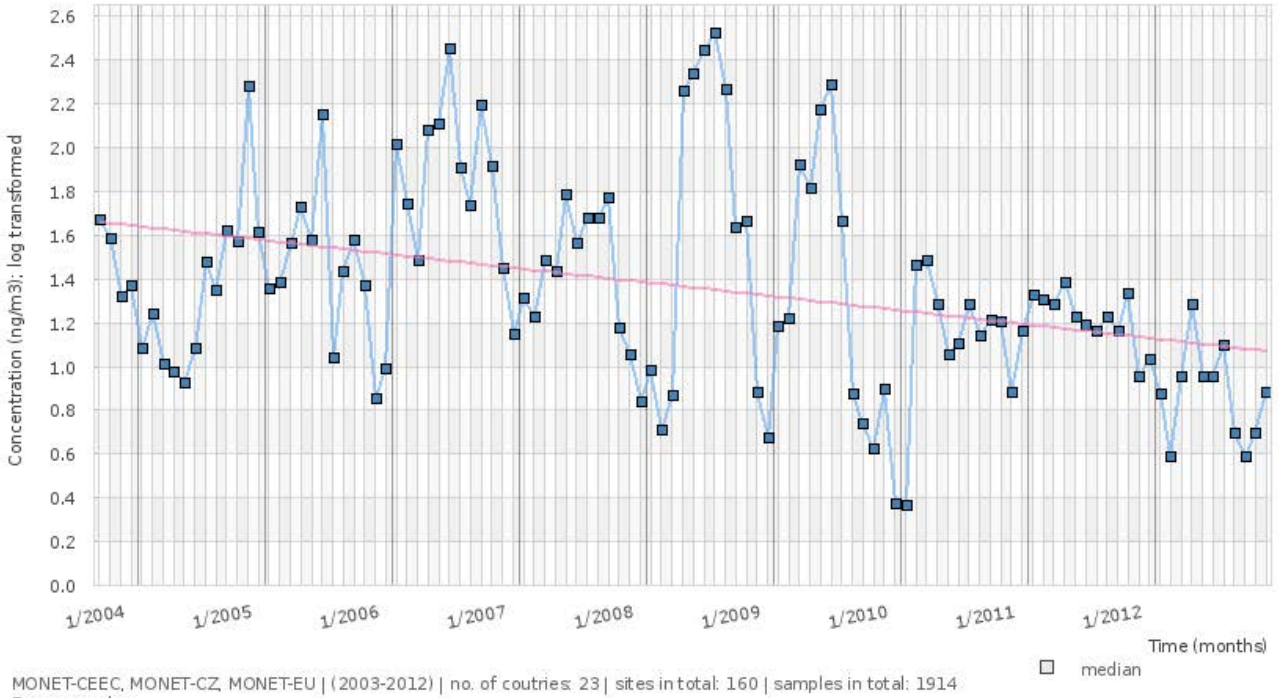
genasis

Browser of RECETOX data

MONITORING OVERVIEW | SAMPLING FREQUENCIES | REPORTED VALUES | TIME SERIES | SEASONALITY ANALYSIS | CORRELATION ANALYSIS

data selection | 2039 samples, 160 site(s) | projects: MONET-CEEC, ...(3)

Alpha-HCH (air passive) time series trend



MONET-CEEC, MONET-CZ, MONET-EU | (2003-2012) | no. of coutries: 23 | sites in total: 160 | samples in total: 1914
Base: samples
www.genasis.cz

Σ SUMMARY

TRENDS

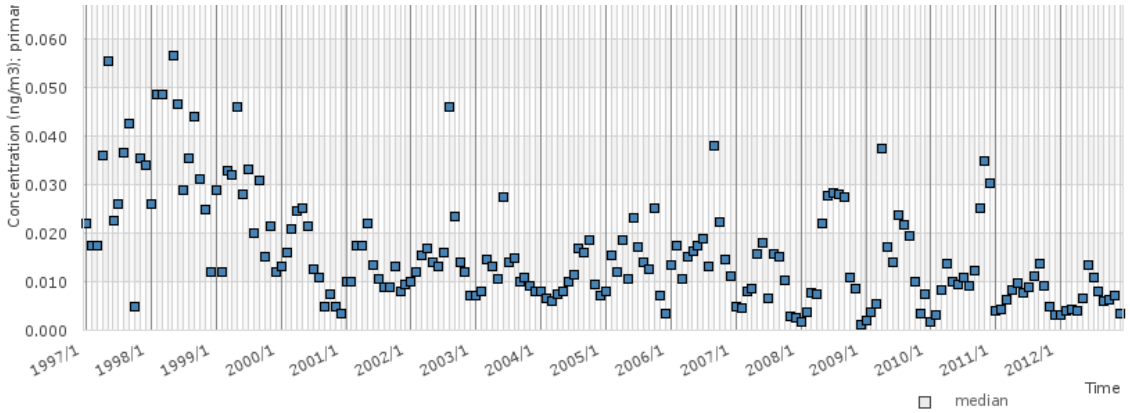
Compound/Parameter

Analysis settings

Stratification

Filter

Time series and trend analysis



Analysis settings

Stratification

Filter

KOSETICE-INTEGR | (1997-2012) | no. of coutries: 1 | sites in total: 1 | samples in total: 829
Base: sites
www.genasis.cz

Median (5th - 95th percentile)	**0.0122** (0.0021 - 0.0510) ng/m^3
Median (25th - 75th percentile)	**0.0122** (0.0070 - 0.0220) ng/m^3
Minimum - maximum	**0.0003** - **0.2120** ng/m^3
Geometric mean (95% CI)	**0.0117** (0.0016 - 0.0880) ng/m^3
Arithmetic mean (95% CI)	**0.0183** (0.0000 - 0.0574) ng/m^3
Trend tests	
Daniels test	-0.511 ($p < 0.001$)
Mann - Kendall test	-0.356 ($p \geq 0.05$)
Trend estimates	
Difference between beginning/end of time series 1/1997 - 12/2012	-0.0185 ng/m^3 (-84.1045%)
Annual change based on difference between beginning/end of time series	-0.0012 ng/m^3 (-5.2841%)
Annual change estimated using least square method	-0.0013 ng/m^3 (-6.0911%)

Citation: Jarkovský J., Dušek L., Kubásek M., Kohút L., Klánová J., Hůlek R., Gregor J., Šebková K., Borůvková J., Hřebíček J., Holoubek I. (2011)
On-line data browser for environmental monitoring and associated information systems [online].
Masaryk University, 2012 [cit. 2012-04-02]. Available from www.genasis.cz. Version 3.9. (only air monitoring) - data export June 2013 [2013]

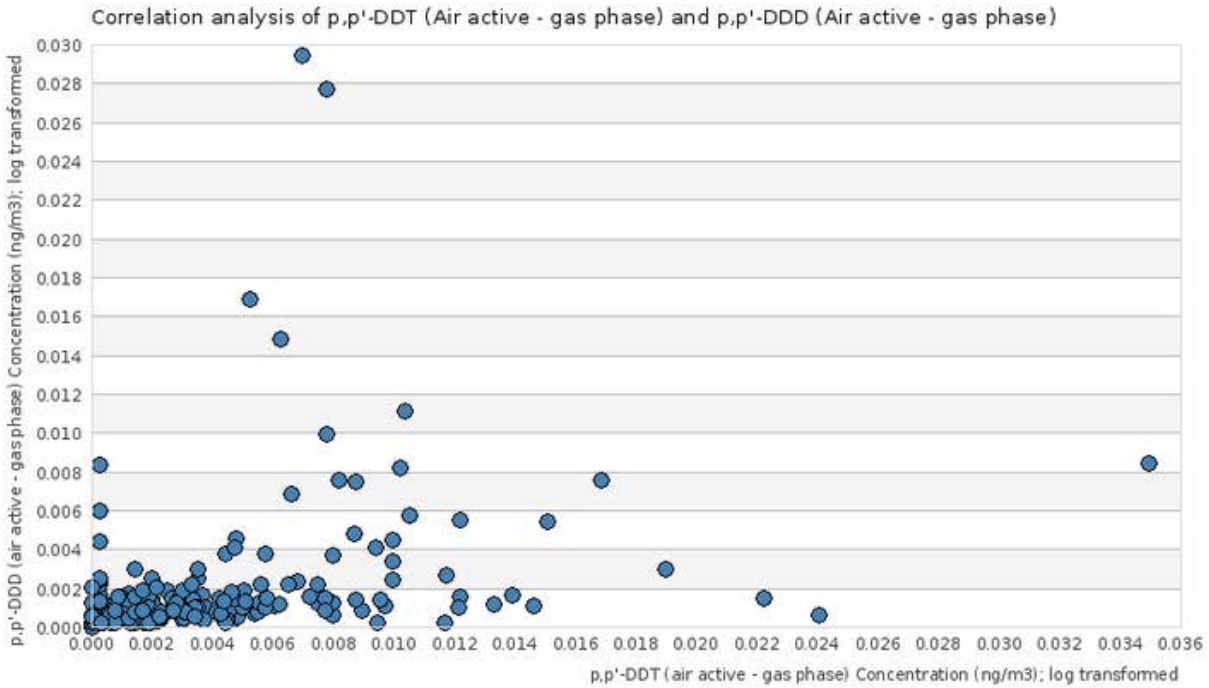
Correlation analysis

GENASIS | Global data | National data | RECETOX data | Case studies

Browser of RECETOX data

MONITORING OVERVIEW | SAMPLING FREQUENCIES | REPORTED VALUES | TIME SERIES | SEASONALITY ANALYSIS | CORRELATION ANALYSIS

data selection | 3276 samples, 22 site(s) | projects: KOSETICE-INTEGR, ...(2)



KOSETICE-INTEGR, MONET-CZ | (1993-2012) | no. of coutries: 1 | sites in total: 1 | samples in total: 914
Base: samples
www.genasis.cz

Correlations	
Pearson correlation	0.299 ($p < 0.001$)
Spearman correlation	0.481 ($p < 0.001$)

2 COMPOUNDS CORRELATION

Compound 1

Compound 2

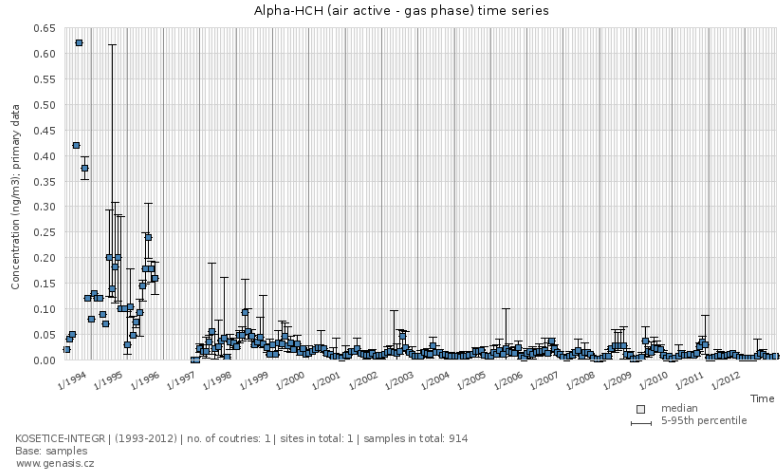
Analysis settings

Stratification

Filter

Shared features

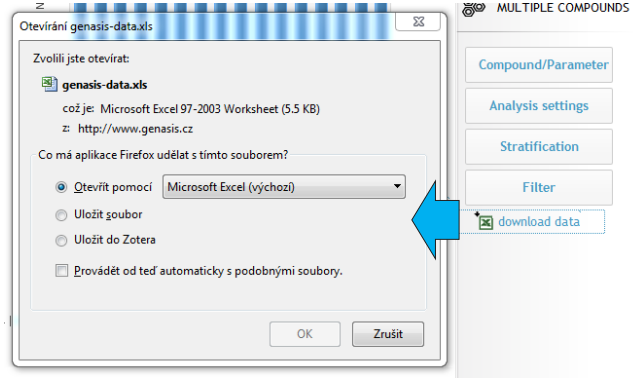
Graphical and tabular outputs



Show Summary table

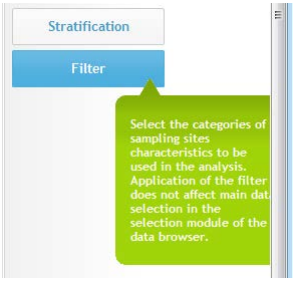
Median (5th - 95th percentile)	0.0122 (0.0021 - 0.0510) ng/m³
Median (25th - 75th percentile)	0.0122 (0.0070 - 0.0220) ng/m³
Minimum - maximum	0.0003 - 0.2120 ng/m³
Geometric mean (95% CI)	0.0117 (0.0016 - 0.0880) ng/m³
Arithmetic mean (95% CI)	0.0183 (0.0000 - 0.0574) ng/m³
Trend tests	
Daniels test	-0.511 (p < 0.001)
Mann - Kendall test	-0.356 (p ≥ 0.05)
Trend estimates	
Difference between beginning/end of time series 1/1997 - 12/2012	-0.0185 ng/m³ (-84.1045%)
Annual change based on difference between beginning/end of time series	-0.0012 ng/m³ (-5.2841%)
Annual change estimated using least square method	-0.0013 ng/m³ (-6.0911%)

Export of outputs



Filtering and splitting of selected data according to set of sampling sites characteristics

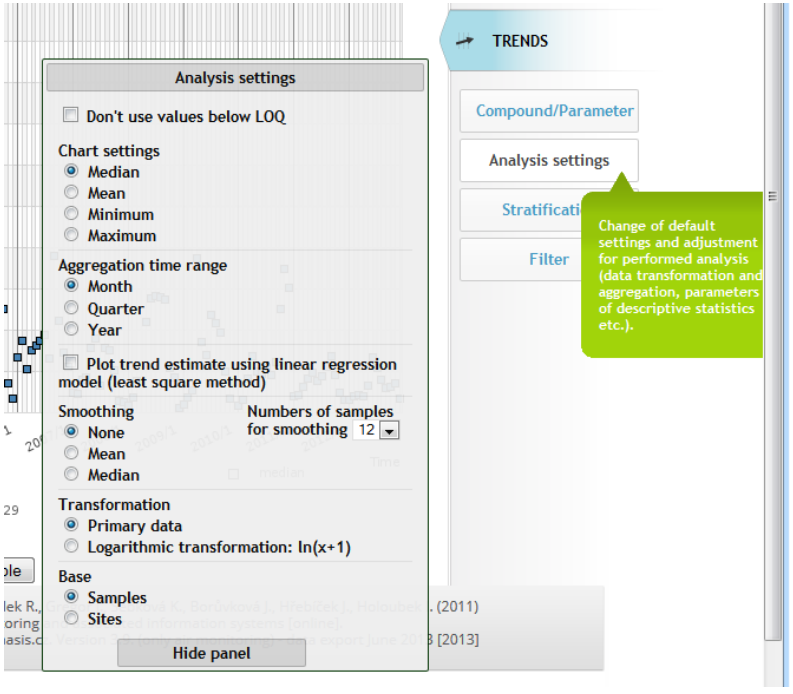
due to dynamic structure of the database these sampling sites characteristics can be easily enriched by newly available data



Analysis specific settings

data transformation

parametric and nonparametric statistics and trend tests are provided



Conclusion on **GENASIS data browser**

- We introduce a user-friendly system for the visualization and analysis of contamination of all environmental compartments by persistent organic pollutants

- Evaluation of actual POPs contamination, its long-term trends and seasonal fluctuations.

- Project outcomes are useful as information source both for lay public and experts

- Important IT tool for the process of the Stockholm Convention implementation.

CONCLUSION: Standardized IT services can help to skip the gap between heterogeneous primary data and on-line widely accessible reporting

Thank you very much for your kind attention