# Contaminated sites in Poland – present state and perspectives


**Grzegorz Siebielec[1], Tomasz Stuczynski[2], Sylwia Siebielec[1], Agnieszka Klimkowicz-Pawlas[1], Piotr Sugier[3]**

**[1]Institute of Soil Science and Plant Cultivation – State Research Institute, Czartoryskich 8, 24-100 Puławy, Poland**
**[2]KUL**
**[3]Maria Curie-Skłodowska University, Lublin, Poland**

IUNG Institute of Soil Science and Plant Cultivation State Research Institute



INTERNATIONAL CONFERENCE CONTAMINATED SITES 2018
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# PERMANENT MONITORING OF AGRICULTURAL LAND

# PERMANENT MONITORING OF SOIL QUALITY

„Soil Monitoring„ is an element of the State Monitoring of the Environment

Aim: to observe changes in soil quality under agricultural and non-agricultural anthropogenic pressure

Obligation of monitoring, observation of changes and soil quality written in the Environmental Protection Law

Criteria for TE content in the Regulation of Min of Environment (2002) soil quality standards. New regulation in 2016.

Editions: 1995, 2000, 2005, 2010, 2015

Performed by IUNG

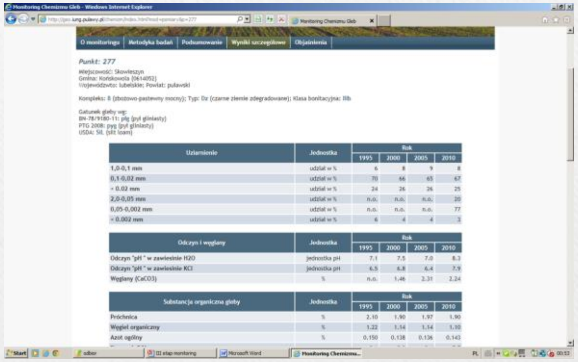
*Financed by State Fund for Env. Prot. and Water Management.*

*Granted by Chief Inspectorate of Environmental Protection*

# Monitoring parameters

- Texture
- SOC
- Carbonates –Scheiblera meth.
- pH in 1MKCl and water
- Hydrolytic and exchange acidity
- Exch. Al
- Available P, K, Mg
- Soluble S
- Total C
- Radioactivity
- Salinity
- Exchange cations
- Base cations
- CEC
- CEC saturation with base cations
- Total S
- Total P, Na, Mg, Ca, Fe, Mn, Al, Cu, Ni, Cr, Zn, V, Cd, Co, Pb, Ba, Be, Li, La
- PAH

**Monitoring data – available for public**

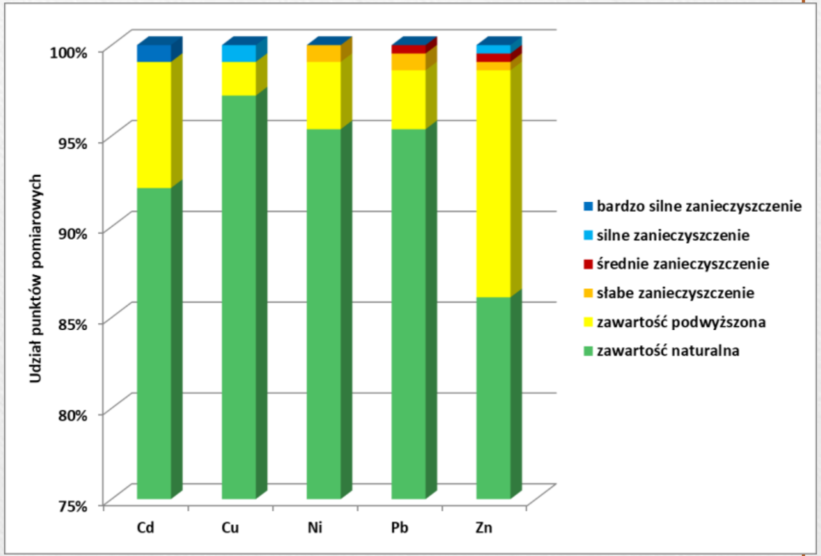


Since 2015:

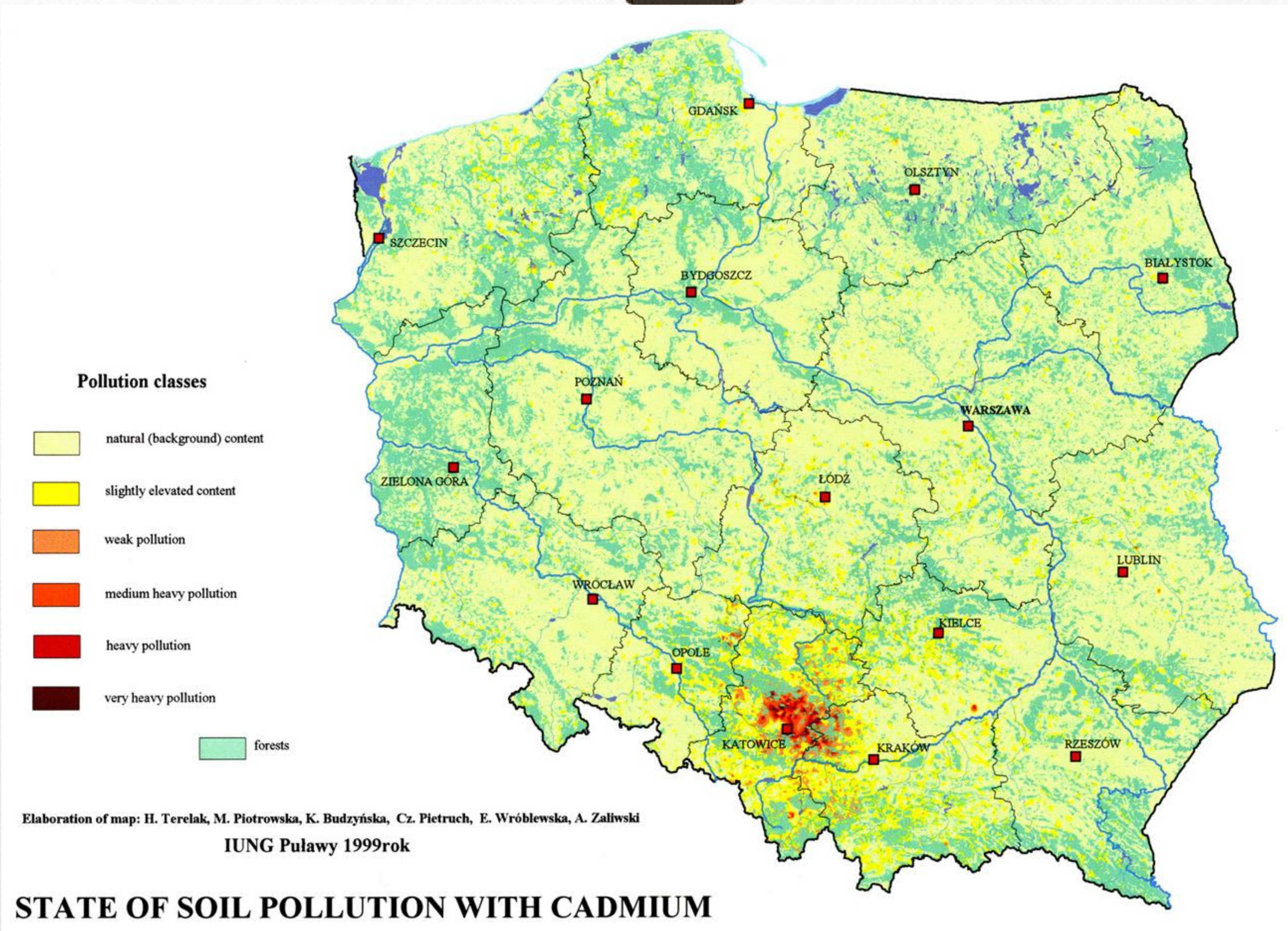
- Hg
- N min
- Pesticides - carbaryl, carbofuran, maneb, atrazine
- Chloroorganic pesticides - DDT/DDE/DDD, aldrine, dieldrine, α-HCH, β-HCH, g-HCH

## TE exceeding thresholds


## Percentage of metal contaminated soil profiles



## LARGE PROGRAMME FOR EVALUATION OF AGRICULTURAL LAND in 1990s

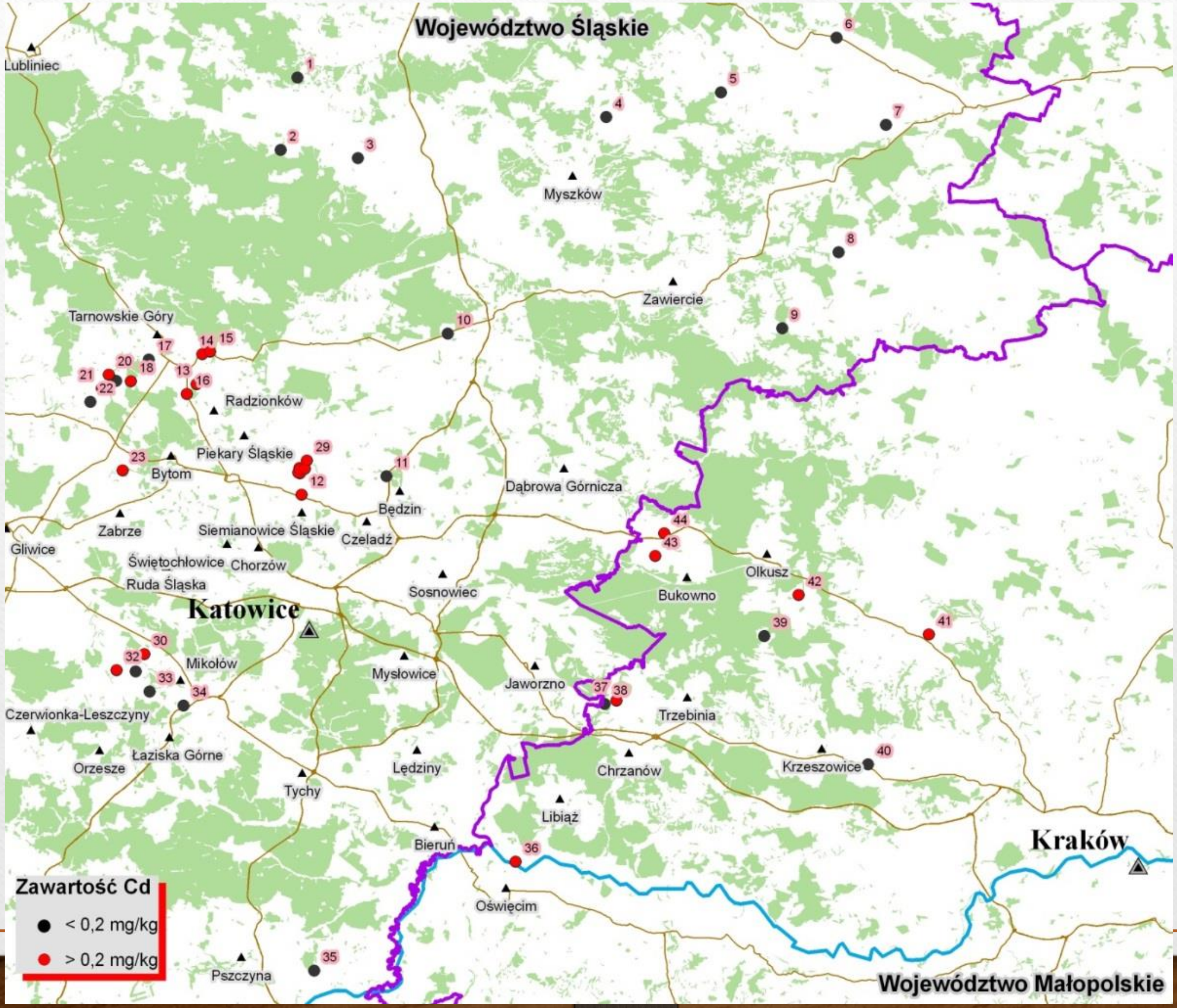


GDAŃSK
OLSZTYN
SZCZECIN
BYDGOSZCZ
BIAŁYSTOK
POZNAŃ
WARSZAWA
ZIELONA GÓRA
ŁÓDŹ
LUBLIN
WROCŁAW
KIELCE
OPOLE
KATOWICE
KRAKÓW
RZESZÓW
Pollution classes
natural (background) content
slightly elevated content
weak pollution
medium heavy pollution
heavy pollution
very heavy pollution
forests
Elaboration of map: H. Terelak, M. Piotrowska, K. Budzyńska, Cz. Pietruch, E. Wróblewska, A. Zaliwski
IUNG Puławy 1999rok
STATE OF SOIL POLLUTION WITH CADMIUM

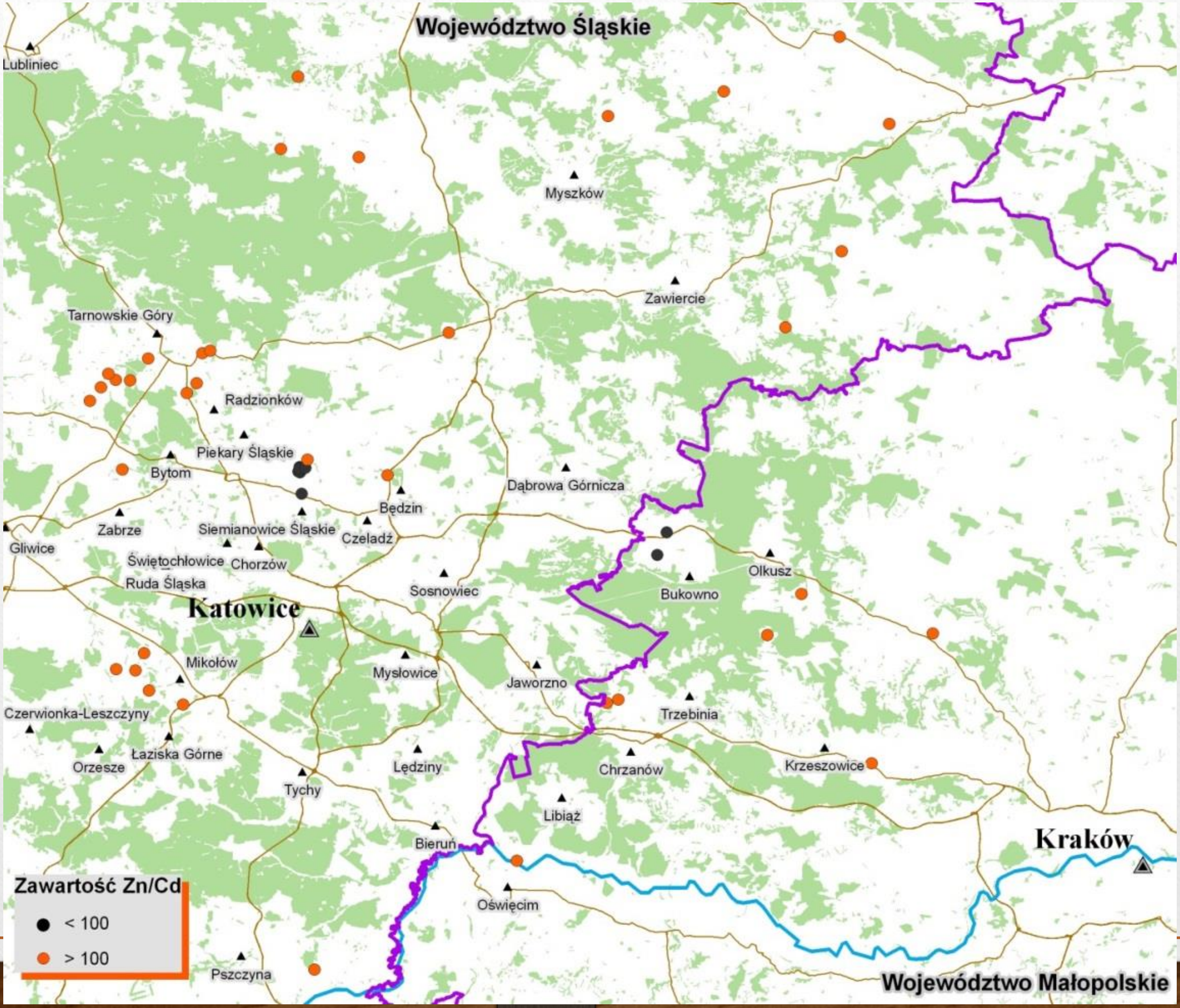
# AGRICULTURAL LAND IN MINING AND SMELTING AREAS

# Location Dołki/near Piekary Śl.

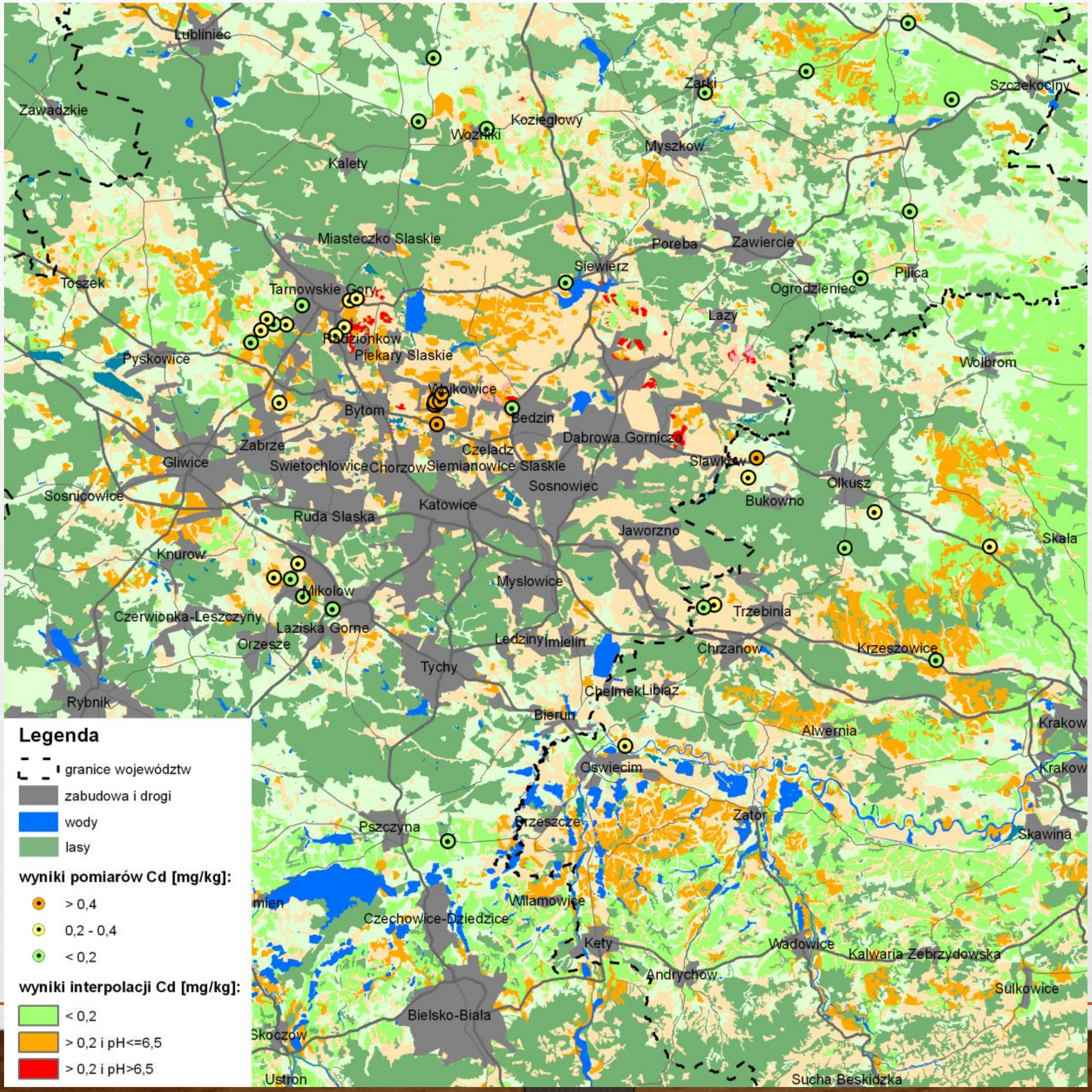
Location of samples excedding the Cd thresholds in wheat grain



Zn/Cd ratio in wheat grain in post-industrial region



# Forecasted grain Cd vs. soil pH



# CONTAMINATED SITES - REGULATIONS

**The Act - Environmental Protection Law** (POŚ), and implementing acts:
- Regulation of the Minister of the Environment of September 1, 2016 on the manner of conducting an assessment of the ground surface pollution,
- Regulation of the Minister of the Environment of September 1, 2016 on the detailed scope of information that is collected in the register of historical soil contamination

**The Act on preventing and repairing damage to the environment**, and executive acts:

Regulation of the Minister of the Environment of September 1, 2016 on the criteria for assessing the occurrence of environmental damage,

Regulation of the Minister of the Environment of September 1, 2016 on the types of remedial actions and the conditions and manner of conducting,

Regulation of the Minister of the Environment of September 1, 2016 on the detailed scope of information that is collected in the register of historical soil contamination

.

**historical pollution** of the earth's surface - it means the pollution, which occurred before April 30, 2007 or results from the activity that was completed before April 30, 2007, it also means damage to the environment in the earth's surface which was caused by an issue or an event from which more than 30 years ago passed years

**remediation** - activities aimed at:
- removing or reducing the amount of substances causing risk,
- controlling and limiting the spread,

so that the contaminated area posee no risk to human health or the environment, including the current and possible future use of the area;

- natural attenuation can be accepted if it brings the most environmental benefits

MINISTERSTWO ŚRODOWISKA

## Thresholds defined for 4 types of land use

RESIDENTIAL

Agricultural

Forest

Ecological

Industrial
Mining
Transport

# Thresholds in topsoil:

| Lp. | Substancja | Dopuszczalne zawartości substancji powodujących ryzyko z podziałem na grupy i podgrupy gruntów | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | II | | | III | IV |
| | | | II-1 | II-2 | II-3 | | |
| **I. METALE I METALOID** | | | | | | | |
| 1. | Arsenic (As) | 25 | 10 | 20 | 50 | 50 | 100 |
| 2. | Barium (Ba) | 400 | 200 | 400 | 600 | 1000 | 1500 |
| 3. | Chromium (Cr) | 200 | 150 | 300 | 500 | 500 | 1000 |
| 4. | Tin (Sn) | 20 | 10 | 20 | 40 | 100 | 350 |
| 5. | Zinc (Zn) | 500 | 300 | 500 | 1000 | 1000 | 2000 |
| 6. | Cadmium (Cd) | 2 | 2 | 3 | 5 | 10 | 15 |
| 7. | Cobalt (Co) | 50 | 20 | 30 | 50 | 100 | 200 |
| 8. | … | … | … | … | … | … | … |

**Stages of identificatiion:**

**Stage I** - determining the activity that may cause pollution in a given area now or in the past
**Stage II** - determination of the list of substances causing the risk that occur in the soil or in the ground is expected
**Stage III** - collection and analysis of available and current sources of information and research relevant for the assessment of the risk of soil or ground contamination with substances that cause risk from the list established in the second stage
**Stage IV** - gathering information necessary for performing preliminary tests and performing preliminary tests
**Stage V** - detailed research that can be used to develop a remediation plan project

# REGISTER OF CONTAMINATED SITES

- Register is coordinated and managed by General Directorate for Environmental Protection

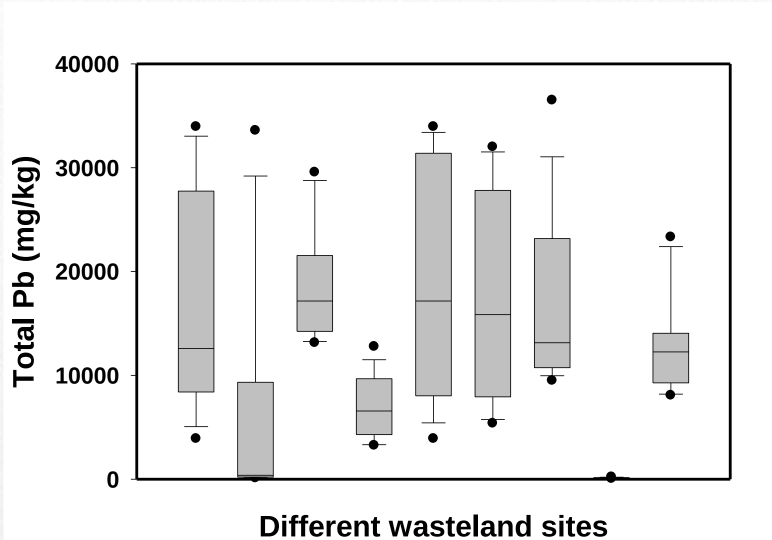
- Regional Directorate for Environmental Protection registers an entry about potential historic contamination of the earth's surface

- Local administration (LAU-1) identifies potential historical polluted sites by:
  determination of activities that may cause historical pollution, carried out before 2007,
  establishing a list of substances that cause risk analysis of available information on the threat of pollution if necessary, the first stage of soil pollution testing
  draws up a list of potential historical pollution of the earth's surface

# POSTINDUSTRIAL SITES – CASE STUDIES
# REVITALISATION

# KWK Gliwice

# Polluted sites in Upper Silesia



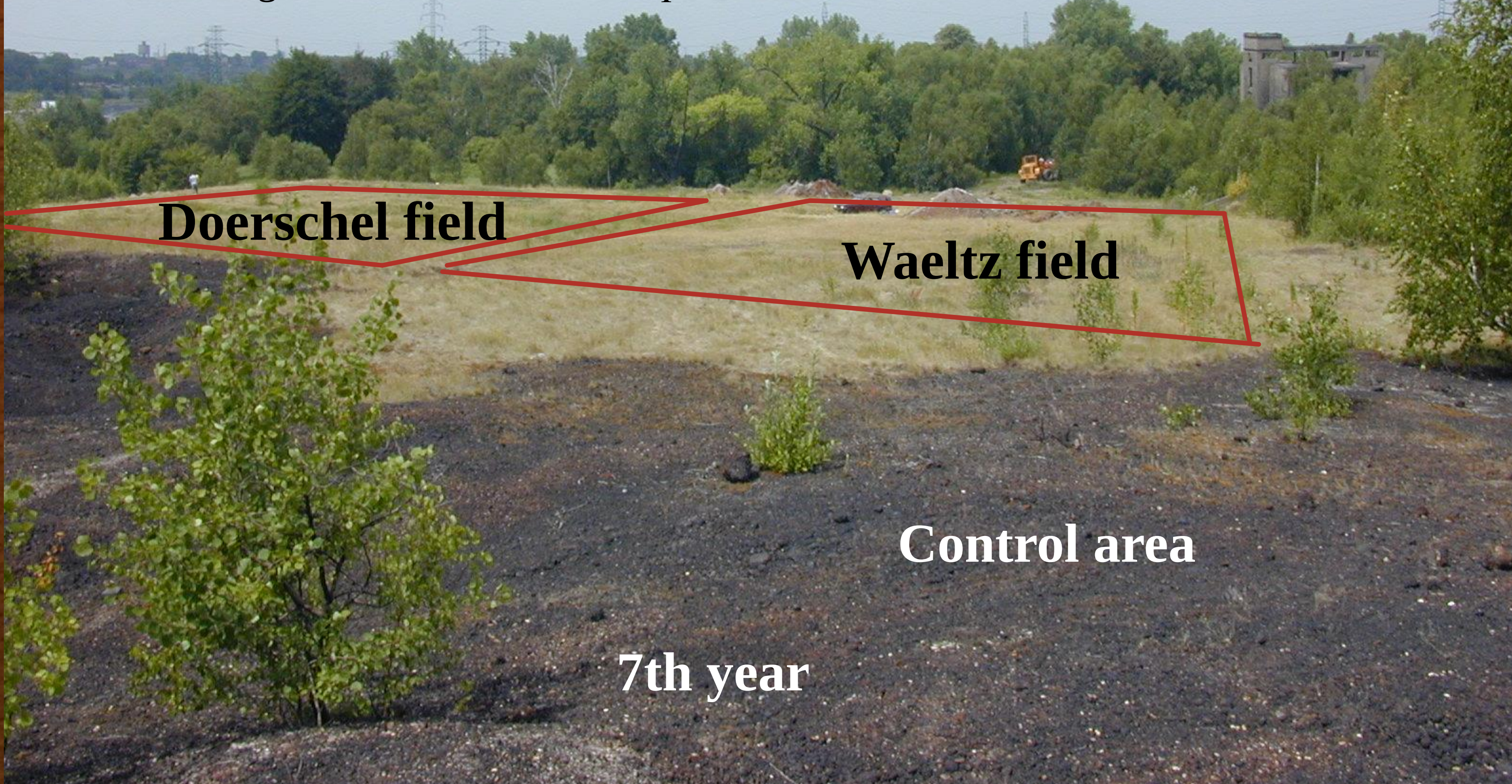

Waeltz waste

Doerschel waste

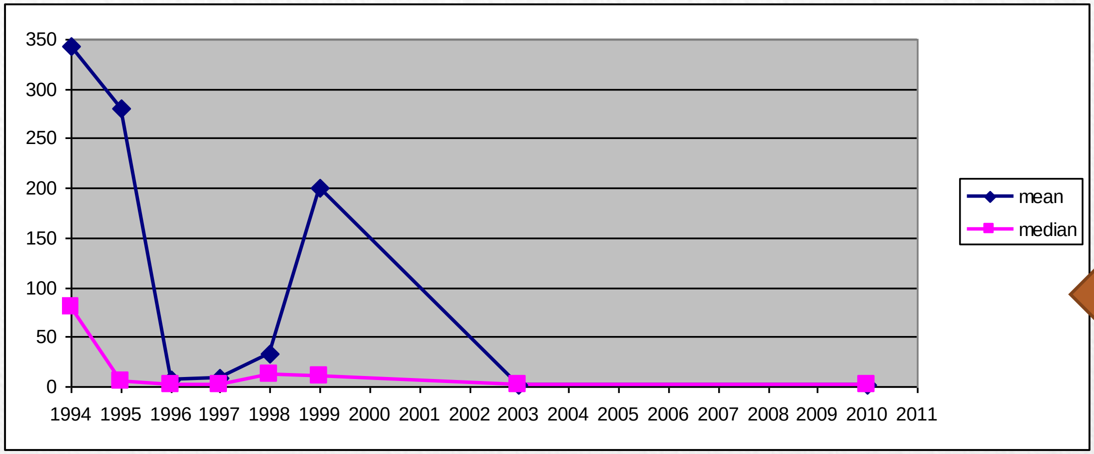
***Each type of heavily contaminated sites requires an individual approach***

# Piekary site I - assisted phytostabilisation of smelter wastelands

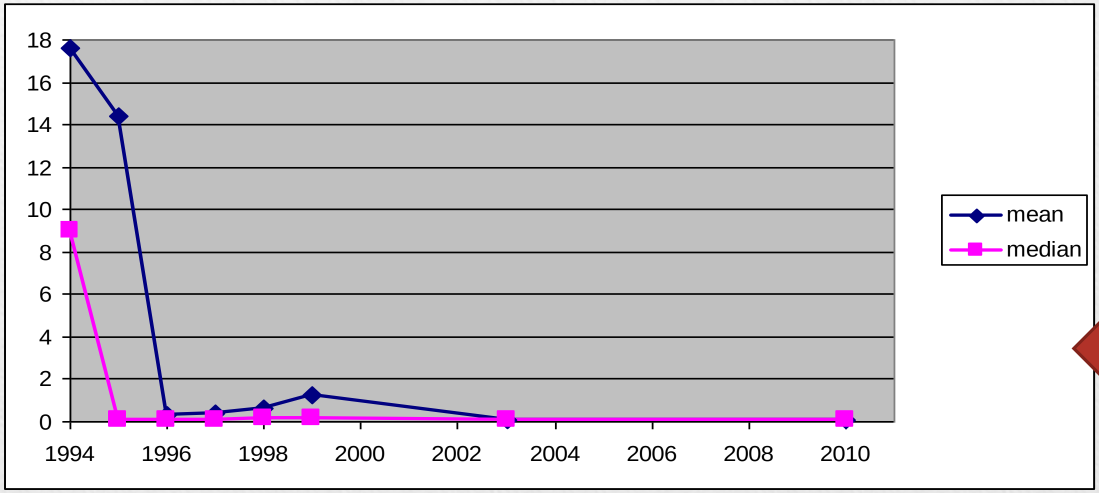
- Demonstration plots of 0.3 – 0.4 hectare were treated with sludge at the rate of 300 t /ha and up to 50t of limestone ($CaO+CaCO_3$)
- Reclaimed sites were monitored for 17 years to characterise mobility of metals and biological activities of the „top soil”.



# Metals solubility before and after amendment with lime and sludge – WELZ waste




Zn water-extr. (mg/kg)




Cd water-extr. (mg/kg)

**Sewage sludges and waste lime can be successfully used for the „one-shot" persistent reclamation of toxic smelter waste**

**Metal contents in plants generally do not pose risk to wildlife and food chain**

# Piekary Site 2 – slag waste (Waeltz type)

## Reclaimed 1997 with biosolids and waste lime; 10 grass species in the plot experiment

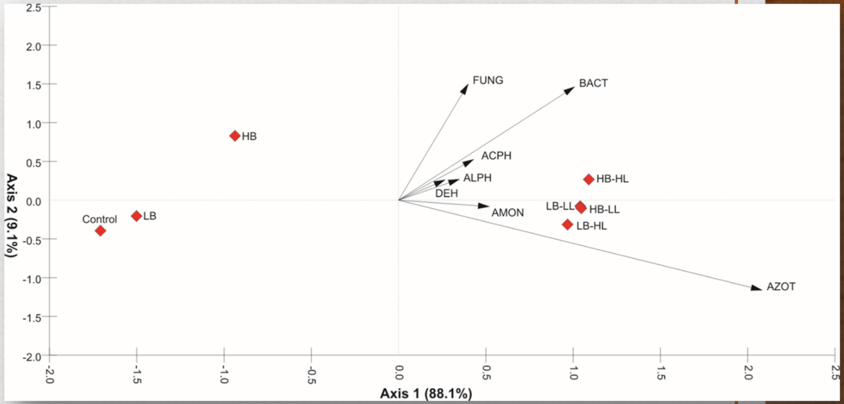
- **Untreated control**,
- **LB -** lower biosolids (150 t $ha^{-1}$),
- **HB** – higher biosolids rate (300 t $ha^{-1}$),
- **LB-LL -** lower biosolids (150 t $ha^{-1}$) and lower lime (100 t $ha^{-1}$) rates,
- **HB-LL -** higher biosolids rate (300 t $ha^{-1}$) and lower lime (100 t $ha^{-1}$) rates,
- **LB-HL -** lower biosolids (150 t $ha^{-1}$) and higher lime (1000 t $ha^{-1}$) rates,
- **HB-HL -** higher biosolids (300 t $ha^{-1}$) and higher lime (1000 t $ha^{-1}$) rates.

# Characteristics of plant cover and plant diversity as dependent on the waste treatment

| Treatment | Cover of herb layer (%) | | Total[1] number of species | Average number of species | | Average number of dicots | | Average number of monocots | | Shannon index | | Evennes index | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mean | SD | | mean | SD | mean | SD | mean | SD | mean | SD | mean | SD |
| Control | $5.7^{a}$ | 1.8 | 9 | $2.6^{a}$ | 0.85 | $2.5^{a}$ | 0.85 | $0^{a}$ | 0.00 | $0.80^{a}$ | 0.41 | $0.93^{c}$ | 0.05 |
| LB | $86.7^{b}$ | 9.0 | 46 | $17.6^{d}$ | 3.50 | $13.9^{c}$ | 3.72 | $3.7^{d}$ | 0.88 | $3.79^{d}$ | 0.32 | $0.92^{c}$ | 0.03 |
| HB | $96.0^{c}$ | 8.3 | 45 | $13.8^{b}$ | 2.12 | $10.9^{b}$ | 1.99 | $2.9^{bc}$ | 0.73 | $3.02^{b}$ | 0.55 | $0.80^{ab}$ | 0.11 |
| LB-LL | $94.7^{c}$ | 8.3 | 40 | $13.8^{bc}$ | 3.45 | $11.1^{b}$ | 3.11 | $2.6^{b}$ | 0.74 | $3.03^{b}$ | 0.62 | $0.80^{ab}$ | 0.10 |
| HB-LL | $95.0^{c}$ | 8.5 | 39 | $14.8^{bc}$ | 3.98 | $10.9^{bc}$ | 3.43 | $3.8^{cd}$ | 1.68 | $3.09^{b}$ | 0.56 | $0.80^{a}$ | 0.08 |
| LB-HL | $97.9^{c}$ | 4.3 | 46 | $17.3^{d}$ | 4.35 | $13.1^{bc}$ | 4.65 | $4.3^{d}$ | 0.98 | $3.48^{c}$ | 0.45 | $0.85^{ab}$ | 0.06 |
| HB-HL | $98.6^{c}$ | 3.6 | 50 | $16.6^{cd}$ | 3.43 | $12.9^{bc}$ | 3.15 | $3.7^{cd}$ | 1.25 | $3.48^{c}$ | 0.43 | $0.86^{b}$ | 0.06 |

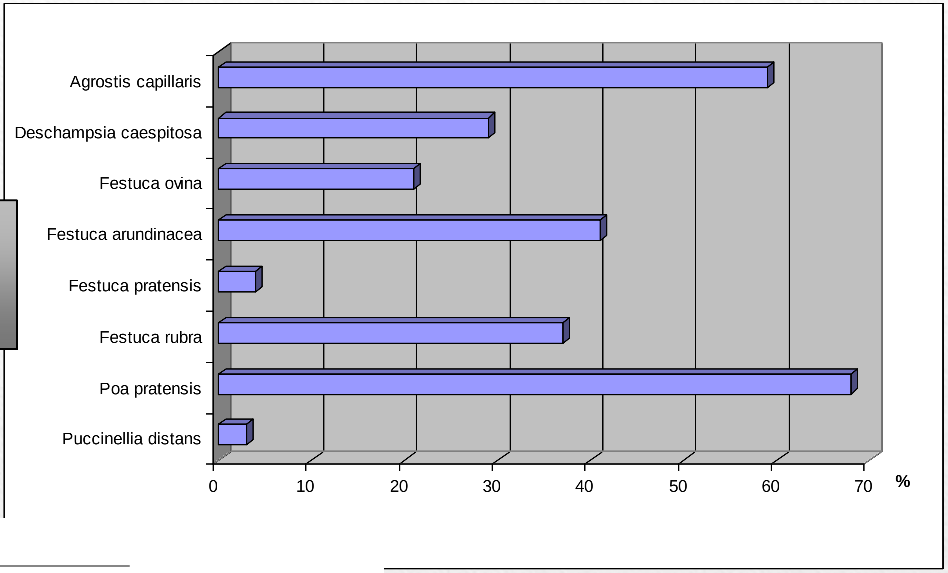
# Microbial indices

| Treatment | Total number of bacteria Azotobacter | | Total number of ammonification bacteria | |
|---|---|---|---|---|
| | $10^{1}$ CFU $g^{-1}$ d.m. of soil | | $10^{7}$ CFU $g^{-1}$ d.m. of soil | |
| Control | $0.00^{a}$ | 0.00 | $0.25^{a}$ | 0.15 |
| LB | $0.00^{a}$ | 0.00 | $1.80^{ab}$ | 1.16 |
| HB | $0.00^{a}$ | 0.00 | $0.81^{a}$ | 0.59 |
| LB-LL | $207.64^{bc}$ | 102.60 | $2.97^{b}$ | 0.28 |
| HB-LL | $180.61^{bc}$ | 76.91 | $5.16^{bc}$ | 4.67 |
| LB-HL | $221.17^{d}$ | 19.20 | $5.94^{bc}$ | 3.77 |
| HB-HL | $111.91^{b}$ | 15.14 | $9.44^{c}$ | 2.56 |

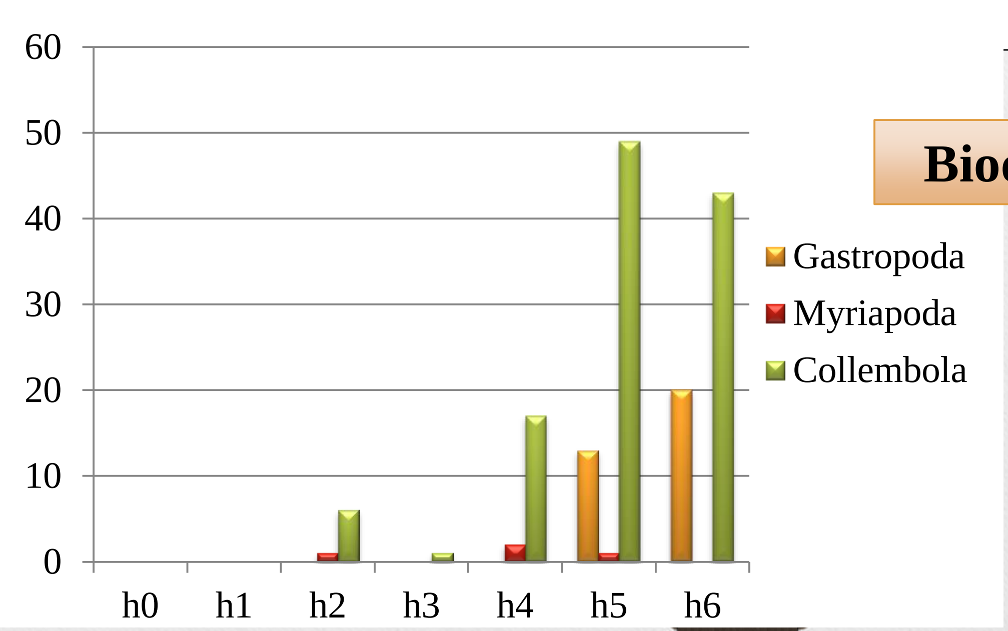



Principal Component Analysis (PCA) for microbiological/biochemical parameters under various waste treatments

## Frequency of original grass species (% of plots)




## Biodiversity of fauna



# EC: EUROPEAN ACHIEVEMENTS IN SOIL REMEDIATION AND BROWNFIELD REDEVELOPMENT

## The decommissioned Piekary Slaskie Zn and Pb ore smelting plant, Poland

**Dr. Grzegorz Siebielec,** gs@iung.pulawy.pl, Department of Soil Science Erosion and Land Protection, Institute of Soil Science and Plant Cultivation-State Research Institute in Pulawy, Poland
**Prof. Tomasz Stuczynski ,** ts@iung.pulawy.pl
Department of Soil Science Erosion and Land Protection, Institute of Soil Science and Plant Cultivation-State Research Institute in Pulawy, Poland

*The study case presents the decommissioned Zn and Pb ore smelting plant located in Piekary Slaskie, Poland. The wasteland had wastes from two different smelting processes — Welz and Doerschel. Both wastes contained extremely high loads of zinc (up to 128 g kg-1), lead (up to 40.6 g kg-1), cadmium (up to 3.46 g kg-1) and arsenic (0.76 g kg-1). The pilot reclamation of smelter waste sites was performed within the framework of the Silesia project. The project was a joint effort by local government, industry and national or international research institutions and agencies: the US Environmental Protection Agency (USEPA), the Centre for Research and Control of the Environment (OBIKS), Virginia Polytechnic Institute, USDA-ARS in Beltsville and the Institute of Soil Science and Plant Cultivation (IUNG). The main objective of the Silesia project was the development of guidelines for the effective and safe use of bio-solids for the reclamation of degraded lands and waste sites.*

**Keywords:** *smelter waste sites, Silesia project, biol-solids, Zn and Pb decommissioned.*

### Introduction

The demonstration was established at the decommissioned Zn and Pb ore smelting plant located in Piekary Slaskie, Poland. The wasteland had wastes from two different smelting processes — Welz and Doerschel. Both wastes contained extremely high loads of zinc (up to 128 g $kg^{-1}$), lead (up to 40.6 g $kg^{-1}$), cadmium (up to 3.46 g $kg^{-1}$) and arsenic (0.76 g $kg^{-1}$). The pilot reclamation of smelter waste sites was performed within the framework of the Silesia project. The project was a joint effort by local government, industry and national or international research institutions and agencies: the US Environmental Protection Agency (USEPA), the Centre for Research and Control of the Environment (OBIKS), Virginia Polytechnic Institute, USDA-ARS in Beltsville and the Institute of Soil Science and Plant Cultivation (IUNG).

The main objective of the Silesia project was the development of guidelines for the effective and safe use of biosolids for the reclamation of degraded lands and waste sites.

### The problem

In the 1990s metal waste sites in the Silesia region were known to contain more than 87 million t of waste. The deposited wastes, containing several per cent zinc and lead, had become a hazard to humans and the environment through leaching and wind erosion (picture of barren smelter wasterland in Piekary before the reclamaton). It must be noted that smelter or mining wastelands are dispersed within the mosaic of various land uses in the region: settlements, arable lands, hobby gardens, parks. This creates a range of various pathways for negative impact from the wastelands, which are generally barren and susceptible to dispersion of pollutants. Spontaneous vegetation processes are very slow and inefficient in terms of reducing health and environmental risks. Therefore it was evident that a simple and cost effective



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ELSEVIER

## Long term insight into biodiversity of a smelter wasteland reclaimed with biosolids and by-product lime

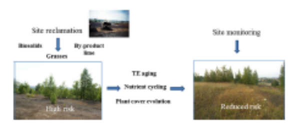
Sylwia Siebielec [a], Grzegorz Siebielec [b,*], Tomasz Stuczyński [c], Piotr Sugier [d], Emilia Gręda [a], Jarosław Grządziel [a]

[a] Department of Microbiology, Institute of Soil Science and Plant Cultivation – State Research Institute, Czartoryskich 8, 24-100 Pulawy, Poland
[b] Department of Soil Science Erosion and Land Protection, Institute of Soil Science and Plant Cultivation – State Research Institute, Czartoryskich 8, 24-100 Pulawy, Poland
[c] Faculty of Mathematics Informatics and Landscape Architecture, The John Paul II Catholic University of Lublin, Konstantynów 1 H, 20-708 Lublin, Poland
[d] Department of Ecology, Faculty of Biology and Biotechnology, Maria Curie-Sklodowska University, Akademicka 19, 20-033 Lublin, Poland

### HIGHLIGHTS

- Biodiversity of a smelter wasteland was evaluated 20 years after the reclamation.
- Biosolids and lime treatments enabled permanent phytostabilisation.
- The tested rates of lime and biosolids seemed to be sufficient for achieving adequate vegetative cover and biodiversity.
- N fixing bacteria are abundant in the plots treated with biosolids and lime.

### GRAPHICAL ABSTRACT

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### ABSTRACT

Smelter wastelands containing high amounts of zinc, lead, cadmium, and arsenic constitute a major problem worldwide. Serious hazards for human health and ecosystem functioning are related to a lack of vegetative cover, causing fugitive dust fluxes, runoff and leaching of metals, affecting post-industrial ecosystems, often in heavily populated areas. Previous studies demonstrated the short term effectiveness of assisted phytostabilisation of zinc and lead smelter slags, using biosolids and liming. However, a long term persistence of plant communities introduced for remediation and risk reduction has not been adequately evaluated.
The work was aimed at characterising trace element solubility, plant and microbial communities of the top layer of the reclaimed zinc and lead smelter waste heaps in Piekary Slaskie, Poland, 20 years after the treatment and revegetation. The surface layer of the waste heaps treated with various rates of biosolids and the by-product lime was sampled for measuring chemical and biochemical parameters, which are indicative for metals bioavailability as well as for microorganisms activity. Microbial processes were characterised by enzyme activities, abundance of specific groups of microorganisms and identification of N fixing bacteria. Plant communities of the area were characterised by a percent coverage of the surface and by a composition of plant species and plant diversity. The study provides a strong evidence that the implemented remediation approach enables a sustainable functioning of the ecosystem established on the toxic waste heaps. Enzyme activities and the count of various groups of microorganisms were the highest in areas treated with both biosolids and lime, regardless their rates. A high plant species diversity and microbial activities are sustainable after almost two decades from the treatment, which is indicative of a strong resistance of the established ecosystem to a metal stress and a poor physical quality of the anthropogenic soil formed by the treatment.

# OPTIMIZING SOIL AMENDMENTS FOR PHYTOSTABILISATION STRATEGIES

# AMENDMENTS

**CaCO3** – reagent grade

**Drinking water residue**

pH 7.8, OM 3%, Fe 1.8%, Mn 7.2%, Al 0.63%, Ca 1.6%,

**Ca - phosphate** – reagent grade CaHPO4

**GWDA compost** – municipal green waste and sludge as feedstock

pH 6.1, OM 27%, Fe 1.9%, Mn 0,03%, Al 1.3%, Ca 2.6%,

**Thomas basic slag (TBS)-** steel manufacture by-product

pH 11.9, high Fe, Mn, Al, Ca, rich in P

**Linz - Donawitz slag (LD) –** steel industry by-product

pH 13.2, Fe 22.9%, Mn 3%, Al 1.5%, Ca 7.4%,

**Gravel sludge (GS)**

pH 8.1, Fe 5.2%, Mn 0.1%, Al 2.4%, Ca 4.2%,

**Siderite (SID) –** iron carbonate

pH 8.2, Fe 26%, Mn 1.2%, Al 0.29%, Ca 7.4%,

**Cyclonic ashes (CA)** are a modified aluminosilicate, originating from the fluidized bed burning of coal refuse. The CA used in this experiment originate from a Spanish coal burning plant.

pH 13.1, Fe 4.7%, Mn 0.03%, Al 8%, Ca 30%,

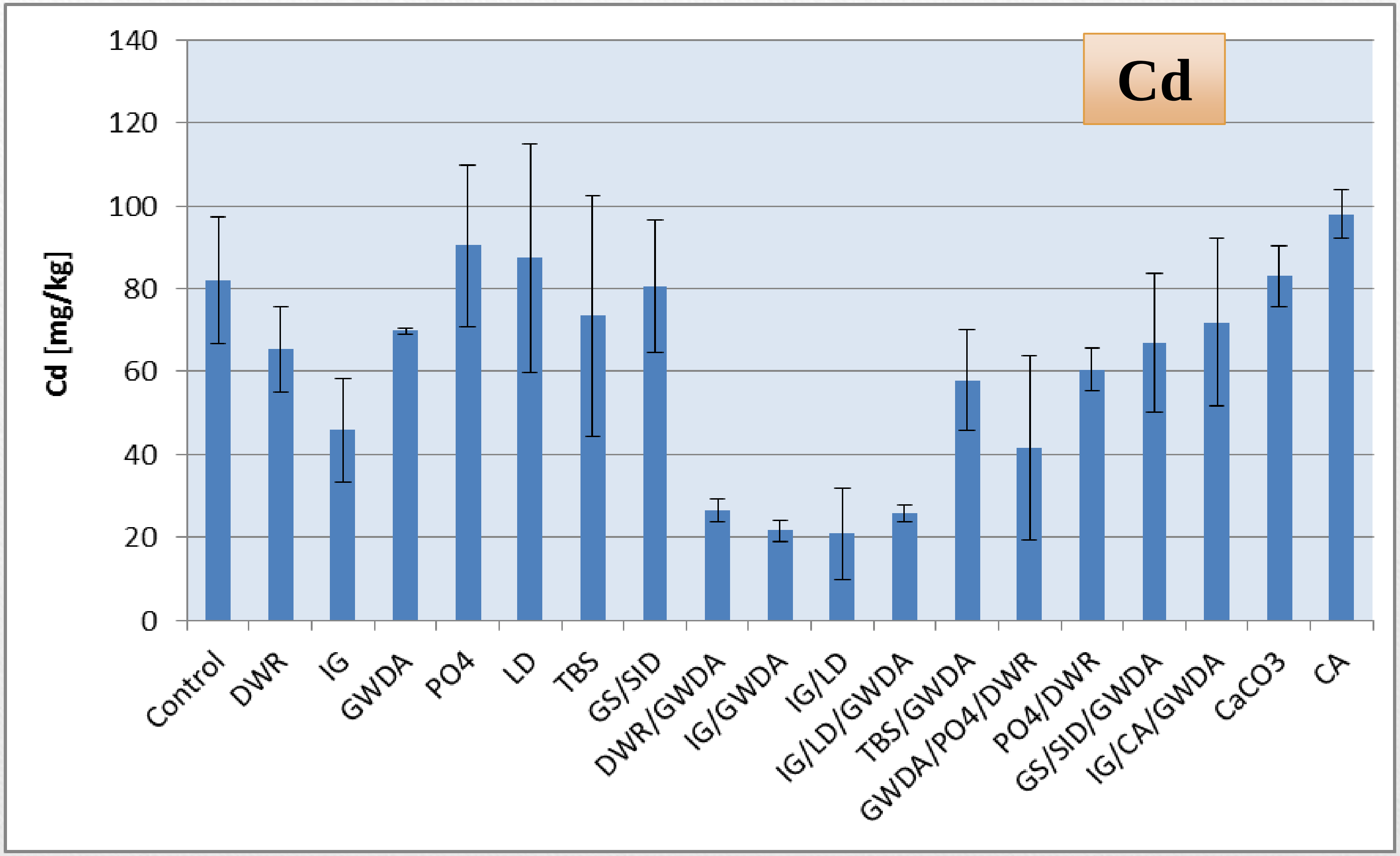
**Iron grit (IG)** - Steel shots are an industrial material intended for shaping metal surfaces prior to coating. They consist mainly of iron ($Fe^0$) and contain native impurities such as Mn, Ni or Cr

pH 8.5, Fe, Mn, Al, Ca,

# Iron grit as single amendment vs. Combined with other materials (Soil SS)

# Compost as single amendment vs. Combined with other materials (Soil SS)

# TE in earthwoms as an effect of soil amendments



## CONLUSIONS – STATE AND PERSPECTIVES

- Progress in development/adaptatipn/update of regulations on contaminated sites
- Register of contamination sites implemented – building databases in progres
- Good practice examples available but remediation actins rather slow
- Perspective for more intensive remediation along with clarification and development of regulations
- Progress in science on optimisation of remediation of contaminated sites

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