Effect of coke industry on the ecological state of surrounding land: application of ERA procedure

Agnieszka Klimkowicz-Pawlas, Bożena Smreczak, Barbara Maliszewska-Kordybach

Institute of Soil Science and Plant Cultivation – State Research Institute

Puławy, POLAND

Ecological Risk Assessment (ERA) - US EPA *EPA/630/R-95/002F*

Is a process that evaluates the likelihood that adverse ecological effects may occur as a result of exposure to stress (e.g. contamination)

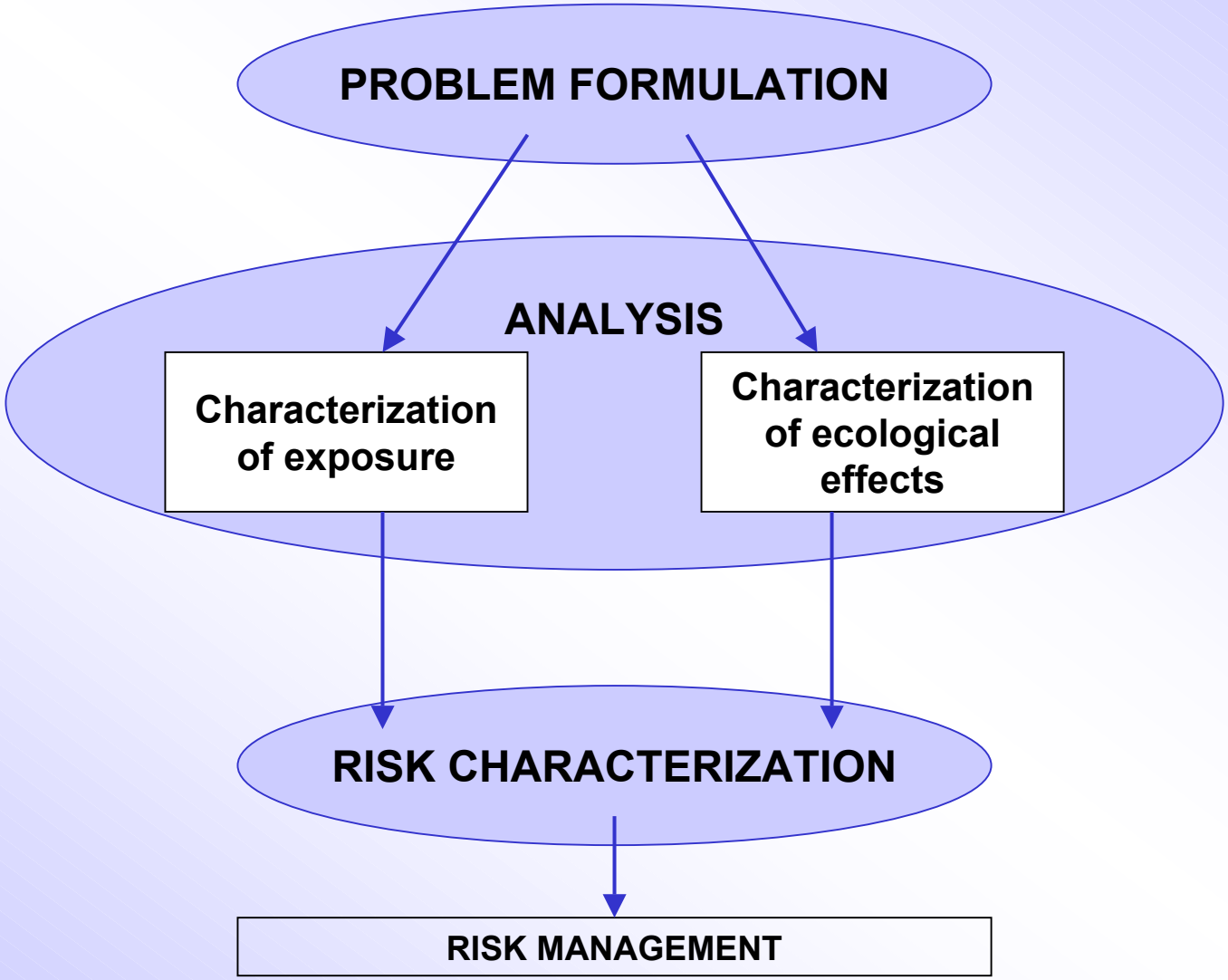
There are typically two major types of ERA:

- **the first one is predictive and often associated with the authorisation and handling of hazardous substances like pesticides or new and existing chemicals in the European Union**

- **the second type of ERA is a description or estimation of changes in populations or ecosystems at specific sites or areas already polluted *(Environmental Effect Assessment)***

Ecological Risk Assessment (ERA) - US EPA

EPA/630/R-95/002F



ERA procedure *(LIBERATION RIVM report Nr 711701047)*

Stage I. Site characterisation and description of land-use

review all available information

site characteristic (soil properties)

information about land use (historical, current and future)

the type of contaminants

Stage II. Determination of ecological aspects

identification of potential ecological receptors

Stage III. Site specific tiered assessment (the Triad)

Tier 1. Simple screening

Tier 2. Refined screening

Tier 3. Detailed assessment

Tier 4. Final assessment

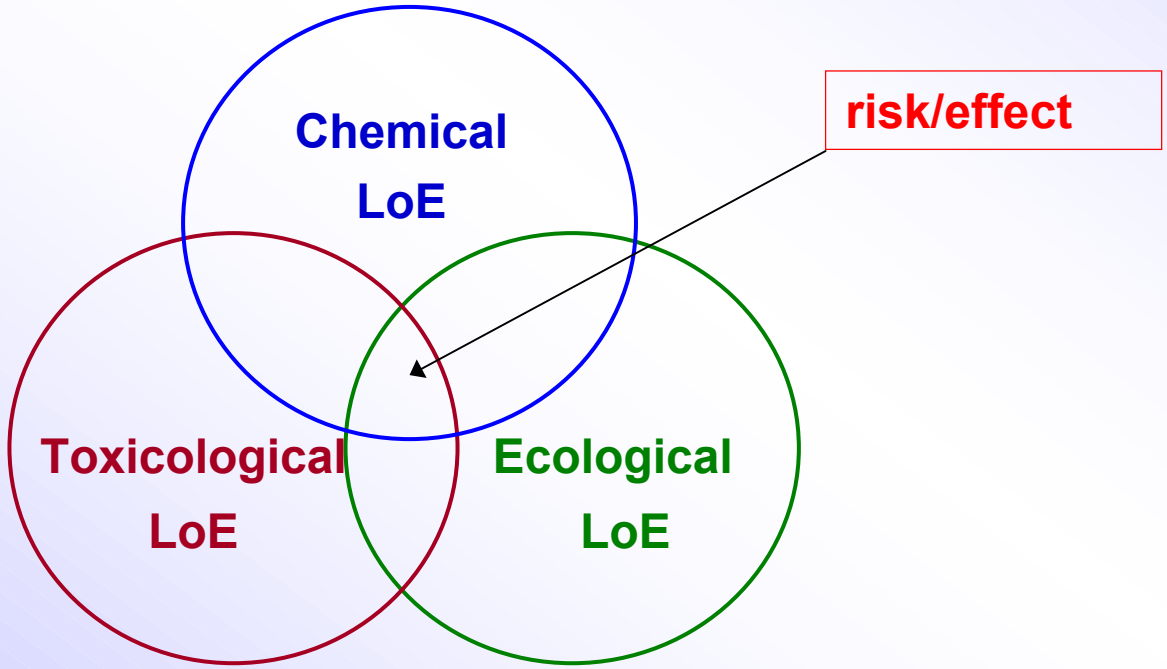
each tier will lead to a decision to proceed or to stop

TRIAD procedure *(Jensen and Mesman 2006)*

The triad is a Weight of Evidence Approach originally developed in order to evaluate sediment quality

This procedure is recently recommended for risk assessment of contaminated soils and was included in the legislation (the Netherlands) and standardisation process (ISO/TC 190 Soil Quality)

The Triad approach exists of three lines of evidence (LoE), the so-called Triad „legs" and is based on the simultaneous and integrated deployment of site-specific chemical, toxicological and ecological information in the risk assessment.



TRIAD procedure

- integration information from 3 different independent LoE will lead to a more precise answer than an approach, which is based solely on the concentration of pollutants at the site

- the multidisciplinary approach will help to minimise the number of false positive or false negative conclusions in ERA

Lines of Evidence – LoE

Chemical (Chem-LoE) – the type and the extent of pollutants, the total or bioavailable concentration of contaminants in the environment, the accumulation in biota (chemical and physicochemical analysis, data from the literature)

Ecotoxicological (Ecotox-LoE) – evaluation of the actual toxicity of contaminants in environmental samples from the site (bioassays in field or in lab)

Ecological (Ecol-LoE) – evaluation of the ecological structure and functioning of the soil (field ecological observations of vegetation, soil fauna, microorganisms at the contaminated site)

Since chemical data alone are not sufficient to evaluate the risk of contaminants in the environment and have to be complemented with results of biological methods

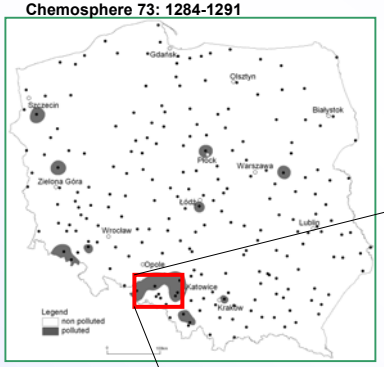
The aim of the study

The aim of the studies was application of the ERA with Triad methodology for the assessment of the area contaminated with PAHs

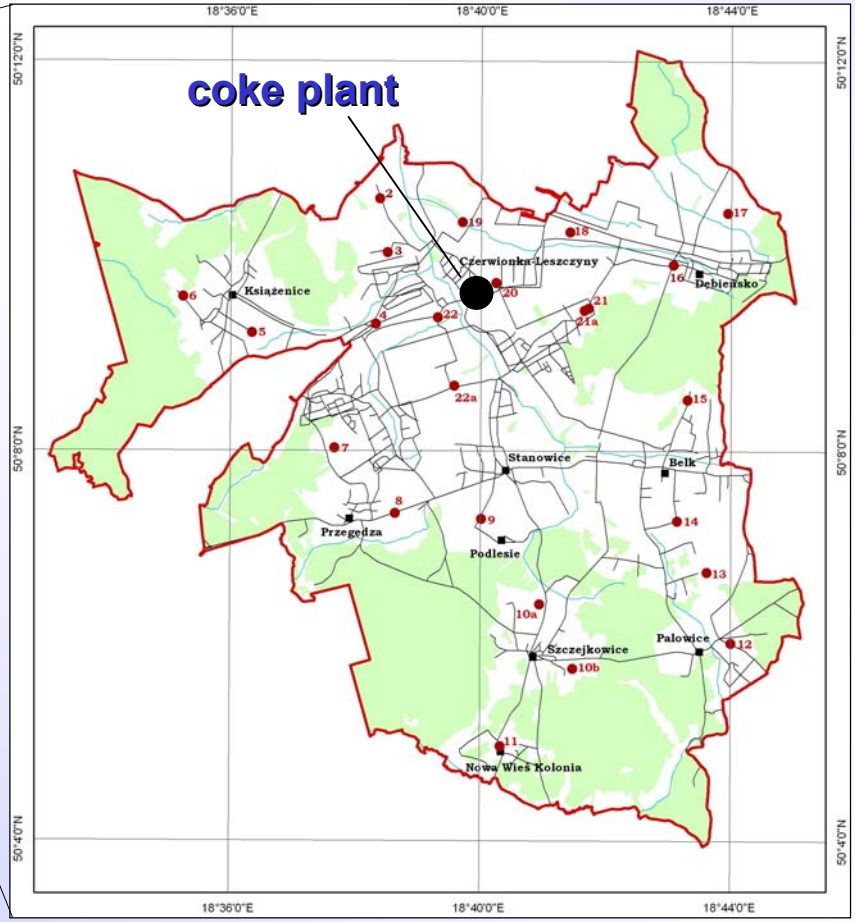
The primary tiers of Triad method (simple and refined screening) were performed

Problem formulation –

Maliszewska-Kordybach *et al.* 2008
Chemosphere 73: 1284-1291



1. Site characterisation – location and contamination sources



location:

agricultural area

about 100 km^2

located in South-West part of Upper Silesia region (Poland)

24 sampling points

sources:

asphalt production

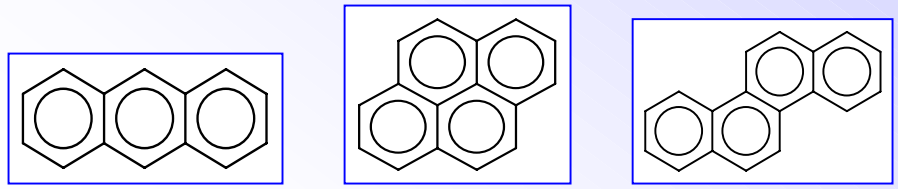
coal mining

road runoffs

coke production

Problem formulation –

1. Site characterisation – expected pollutants



Polycyclic aromatic hydrocarbons:

- are produced in all processes of incomplete combustion of organic materials
- occur in all compartment of the environment, but > 90 % of them concentrates ultimately in soils
- differ substantially in their physical and chemical properties
- are relatively resistant to physical, chemical and biological degradation
- have strong mutagenic, carcinogenic and toxic properties

Problem formulation –

2. Soils characteristic

The following parameters were determined in soil samples:

physicochemical parameters:

particle size distribution (PN-R-04032, 1998)

pH $_{H2O}$, pH $_{KCl}$ (PN-ISO 10390, 1997)

organic matter content (PN-ISO 10694, 2002)

total nitrogen (ISO 11261, 1995)

biological parameters:

dehydrogenases activity (Casida *et al.* 1964)

intensity of respiration (ISO 16072, 2002)

nitrification potential (ISO 15685, 2004)

pollutants content:

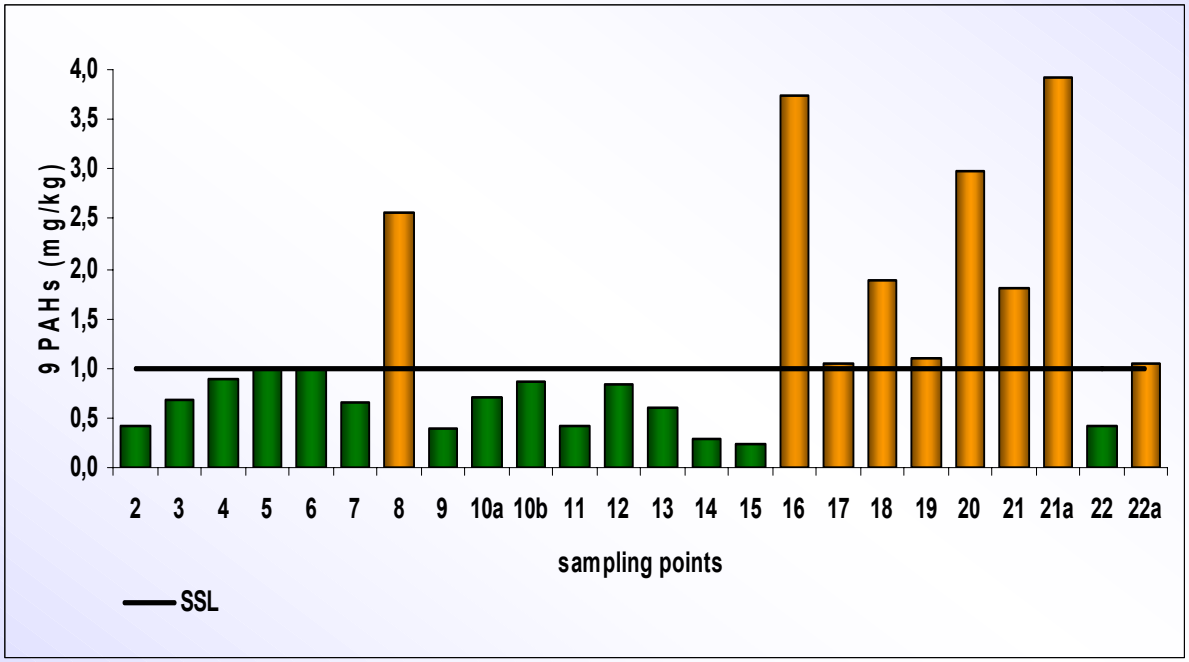
total metal content (ISO 11466, 1995)

total PAHs content (Maliszewska-Kordybach *et al.* 2007)

bioavailable fraction of PAHs (Smreczak *et al.* 2008)

Problem formulation –

Chem-LoE - chemical line of evidence



SSL (*Soil Screening Level*) – limit value according Polish regulation (Dz.U. 2002)

SSL for Σ 9PAHs = 1 mg·kg^{-1},

SSL for BaP = 0,03 mg·kg^{-1}

the problem was identified,
in 42 % of sampling sites the content of PAHs was above the limit value

9 sampling sites need further assessment

Refined screening –

LINES OF EVIDENCE

Chemical (Chem-LoE):

total PAHs content *(Maliszewska-Kordybach et al. 2009)*

Ecotoxicological (Ecotox-LoE):

activity of luminescent bacteria

(Toxi-Screening kit, MicroBioTests Inc., Belgium)

Ecological (Ecol-LoE):

substrate induced respiration *(ISO 14240-1:1997)*

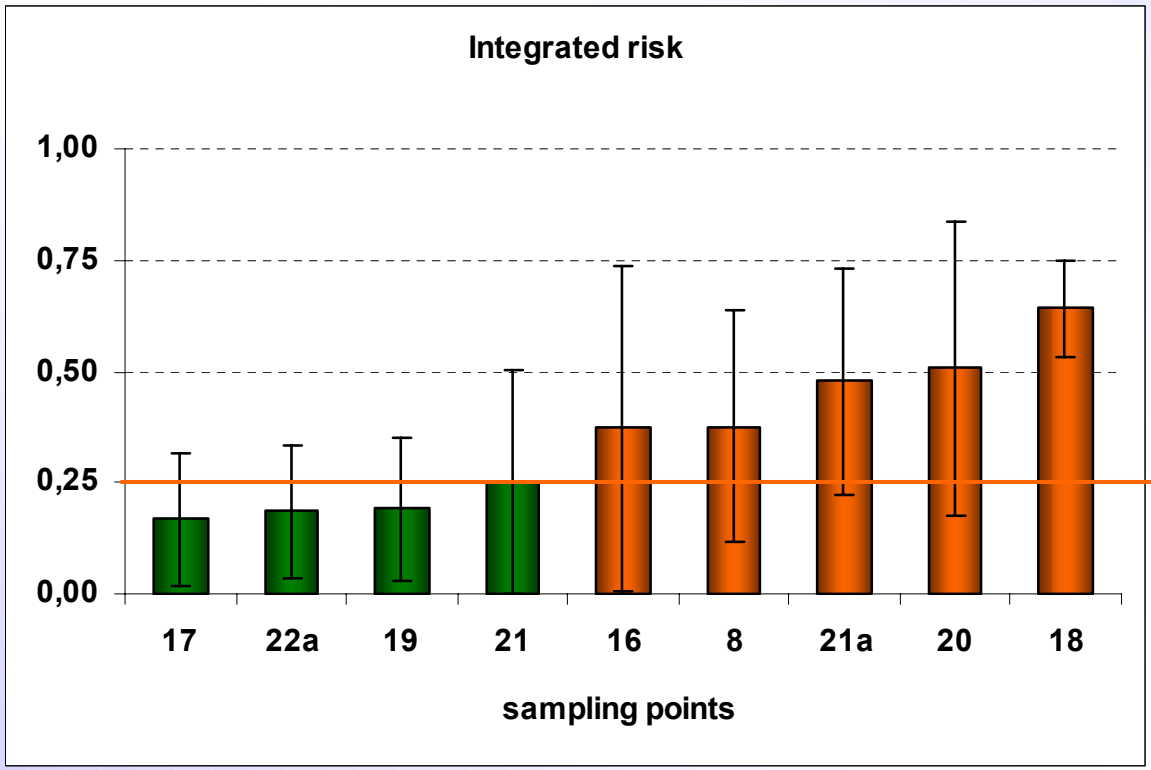
Integration of results from different LoE:

R-Chem-LoE + R-Ecotox-LoE + R-Ecol-LoE = IR

Integrated risk (IR) calculated according Jensen and Mesman proposition *(2006)*

Refined screening –

Integrated risk



Integrated risk (min: 0; max: 1)

IR > 0,25 high risk

Sites 8, 16, 18, 20, 21a located in the vicinity of coke plant need further assessment

- **The first tier of ERA (simple screening) led to selection of the area where risk assessment procedure is really needed**

- **The refined screening enabled the primary evaluation of the risk based on the three lines of evidence (Triad approach)**

- **The risk evaluated on the base of the three lines of evidence decreased in order: R-Chem > R-Ecotox > R-Ecol**

- **The screening procedure permitted on delineation of the limited area of high risk located in the vicinity of the coke plant which have to be included in the further ERA stages**