ENVIRONMENTAL SITE ASSESSMENT: EVALUATION OF CONTAMINATED SOIL POLLUTION BASED ON PHYSICAL-CHEMICAL AND MICROBIOLOGICAL ANALYSES

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ABSTRACT

This paper presents existent levels of soils pollution with organochlorinated pesticides, Lindane and DDT, in the proximity of two former Lindane and DDT suppliers (historical pollution).
There were taken soil samples inside and outside the factories from different depths (20-150 cm). Analytical determination for both locations emphasized the following aspects:

- there are two pollution sources: ex-Lindane/DDT installations and the landfills with HCH isomers and other chlorinated organic compounds;
- the limit values stipulated by Order 756/1997 were exceeded (alert levels) outside the factories (ΣHCH max =637 μg/kg d.w. respectively (ΣHCH max =264 μg/kg d.w.)

Microbiological load (mesophiles) was $2x10^8$ and $4x10^7$ CFU/g at 22^0C and 37^0C respectively (maximum values).
DDT presence in soil was detected only in one studied case and the maximum value was 92 μg ΣDDX/kg d.w. (outside the factory).
Inside the factory/landfill the concentrations levels of HCH isomers and DDX in soil were much higher.

Keywords: isomers, Lindane, DDT, DDX, mesophiles

INTRODUCTION

Persistent organic pollutants (POPs) constitute a diverse group of organic substances, which are toxic, persistent, bioaccumulative and prone to long-range transport. They have different intrinsic physical-chemical properties, which dictate their environmental behavior.
Many countries have environmental problems because of ex industrial production of HCH and DDT.
HCH is a monocyclic chlorinated hydrocarbon. Technical HCH is a mixture of various stereo-isomers, γ-HCH being the most well known as Lindane [6].
The raw product from the chlorination of benzene contains about 14% gamma-isomer HCH and 86% of inactive-isomers: 65-70% alpha-HCH, 14-15% beta-

HCH, approximately 7% delta–HCH, 1-2% epsilon HCH and 1-2% other components.
For each ton of lindane 8-12 tons of HCH-residuals were produced and there are 5-10 million tons of HCH-waste which still exist around the world.
Fortunately, there are some ways to reuse these waste in industrial processes. Well known cases can be found in the Netherlands and in Basque country in Spain were HCH was transformed into TCB.
In Romania, there are two landfills with inactive HCH isomers, which are chosen as case study (historical pollution):

- Ramnicu Valcea city - SC Oltchim SA company in the South;
- Onesti city - SC Chimcomplex SA in the Northeast.

Romania does not use/fabricate Lindane since decades but because of these landfills, this pesticide is still present in soil and water in the proximity of these cities.

EXPERIMENTAL

For both case studies, areas of ex-organochlorinated pesticides factories, proximities of these locations and areas of organic waste landfills were investigated. Figures 1÷3 show the selected sampling points.
Soil samples were taken from different depths 0-150 cm. The investigated areas were 2 km maximum around the ex-factories and landfills.

OLTCHIM sampling points:

- OC1: South of organic waste landfill
- OC2: South East of organic waste landfill, close to Olt River;
- OC3: North East of organic waste landfill, close to Olt River;
- OC4: North of organic waste landfill;
- OC5: North West of organic waste landfill (entrance);
- OC6: East of ex HCH installation;
- OC7: South of ex HCH installation;
- OC8: West of ex HCH installation;
- OC9 (10-30, 20-40): nord fata de fosta instalatie de obtinere HCH;
- OC10: South factory border;
- OC11: West factory border;
- OC12: East factory border;
- OC13: North factory border;
- OC14: 2 km North East organic waste landfill;
- OC15: 2,5 km South organic waste landfill;
- OC16: 2 km South West organic landfill;

CHIMCOMPLEX sampling points:

- B1: outside the factory, left bank of Trotus River;
- B2: outside the factory, Viisoara bridge;
- B3: outside the factory, Radeana village;
- B4: outside the factory, Borzesti village;

- B5: inside the factory, organic waste landfill;
- B6: inside the factory, HCH isomers landfill;
- B8: inside the factory, landfill 1;
- B9: inside the factory, 2,4D pesticide installation;
- B10: inside the factory, landfills 2+3
- B11: inside the factory, industrial and household waste landfill;
- B12: inside the factory, ecological landfill;
- B13 - B16: inside the factory, former HCH installation;
- B17: border with RAFO;
- B18: entrance 2, west border of the factory.

Soil samples were analyzed based on ISO 10382:2002 - Soil quality. Determination of organochlorinated pesticides (OCP) and polychlorinated byphenyls. Gaschromatographic method with electron captures detection. SR EN 6222/2004, DIN EN ISO 11384-3 - Microtox and SR ISO 11266 were used for bacteriological investigation.
Analytical results were compared with Order 756/1997 limits (alert or intervention limits).

No.	HCH isomers	Limits of Order 756/1997 μg/kg d.w.				
		Normal values	Alert limit		Intervention limit	
			Sensitive uses	Less sensitive uses	Sensitive uses	Less sensitive uses
1	αHCH	2	100	300	200	800
2	βHCH	1	50	150	100	400
3	γHCH	1	20	50	50	200
4	δHCH	1	50	150	100	400
5	ΣHCH	5	250	750	500	2000
6	DDT	50	250	750	500	2000
7	DDE	50	250	750	500	2000
8	DDD	50	250	750	500	2000
9	ΣDDT	150	500	1500	1000	4000

RESULTS AND DISCUSSIONS

OLTCHIM case study – figures 1÷4

- There are two sources for historical pollution with organochlorinated pesticides: former HCH installation and the organic waste landfill (which follows closing procedure);
- Soil samples analysis emphasized overtaking of stipulated limits for normal and alert/intervention values. Taking to account sampling points, the maximum values were:
  - Organic waste landfill, North West entrance, OC5 sample (10-30 cm), 1292 μg ΣHCH/kg d.w. (1247 μg γHCH/kg d.w.);
  - Former HCH installation, East, OC6 sample (0-20 cm), 12,8 mg ΣHCH/kg d.w. (553 μg γHCH/kg d.w.);
  - Factory border, East, OC12 sample (80-100 cm), 637 μgΣHCH/kg d.w. (223 μg γHCH/kg d.w.);
  - Outside of landfill, 2 km South East, OC16 sample (0-20 cm), 264 μg ΣHCH/kg d.w. (35 μg γHCH/kg d.w.);
  - Σ DDX (DDT+DDE+DDD) levels were below analytical detection limit;
  - Microbiological (mesofile) load for OC12 sample (80-100 cm) was $2x10^8$ and $4x10^7$ UFC/g for 22 ^{0}C and 37 ^{0}C respectively

Fig.1

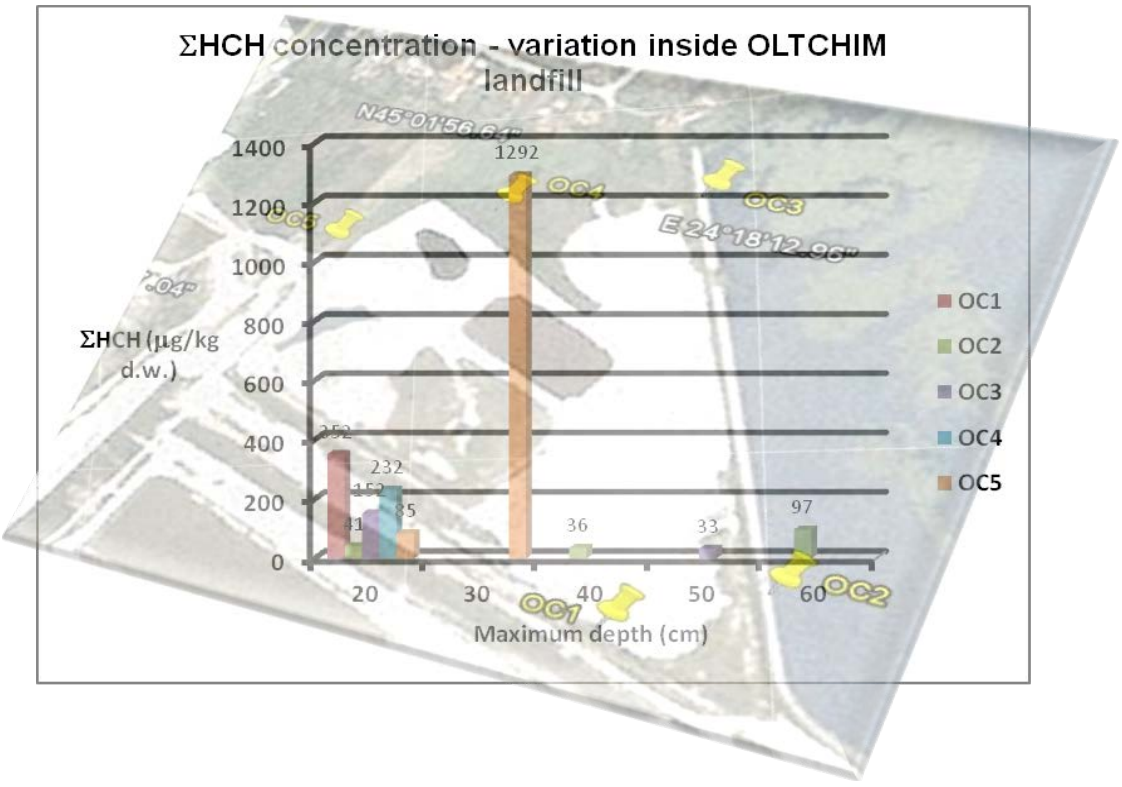


Fig. 2

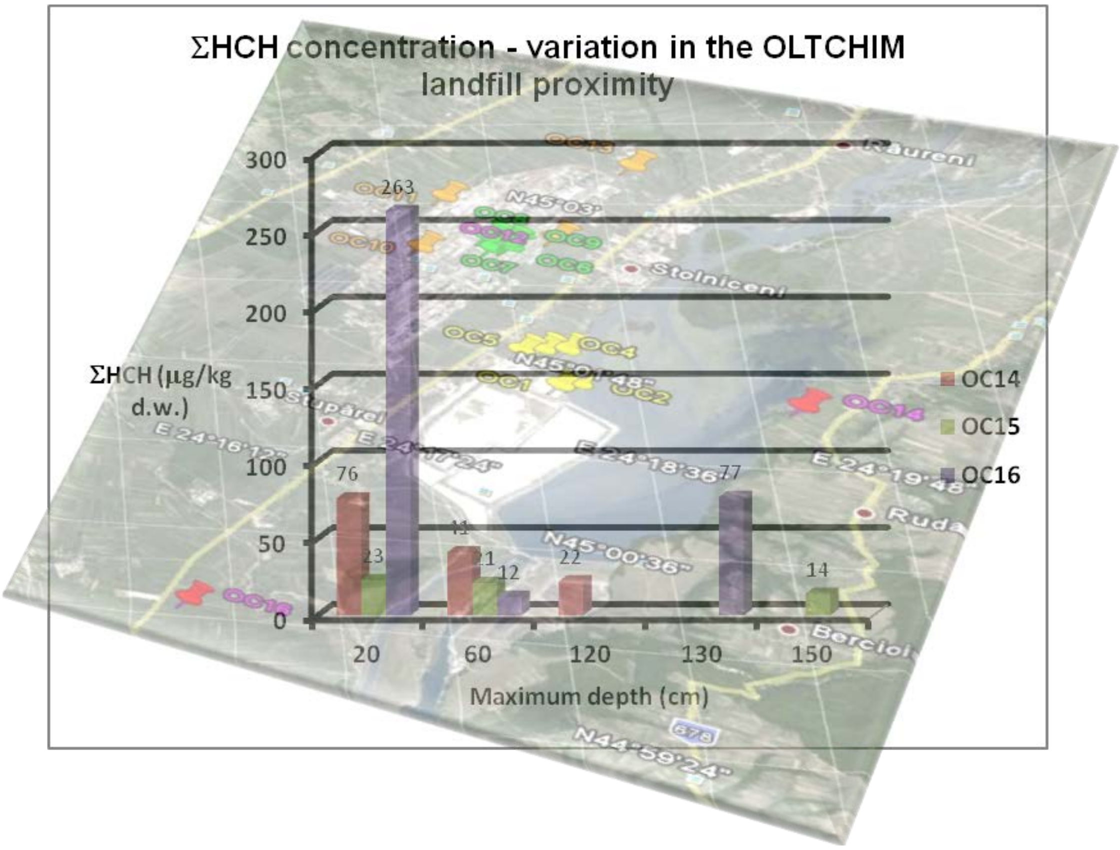

ΣHCH concentration - variation in the OLTCHIM landfill proximity
ΣHCH (µg/kg d.w.)
300
250
200
150
100
50
0
263
76
23
41
21
12
22
77
14
20
60
120
130
150
Maximum depth (cm)
OC14
OC15
OC16

Fig. 3

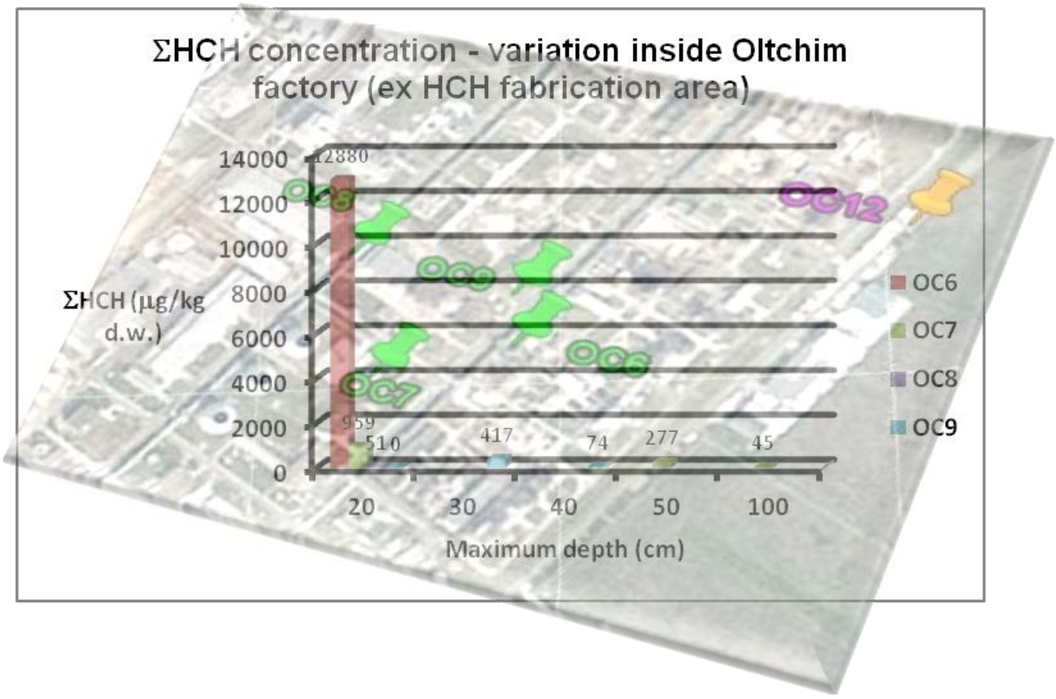
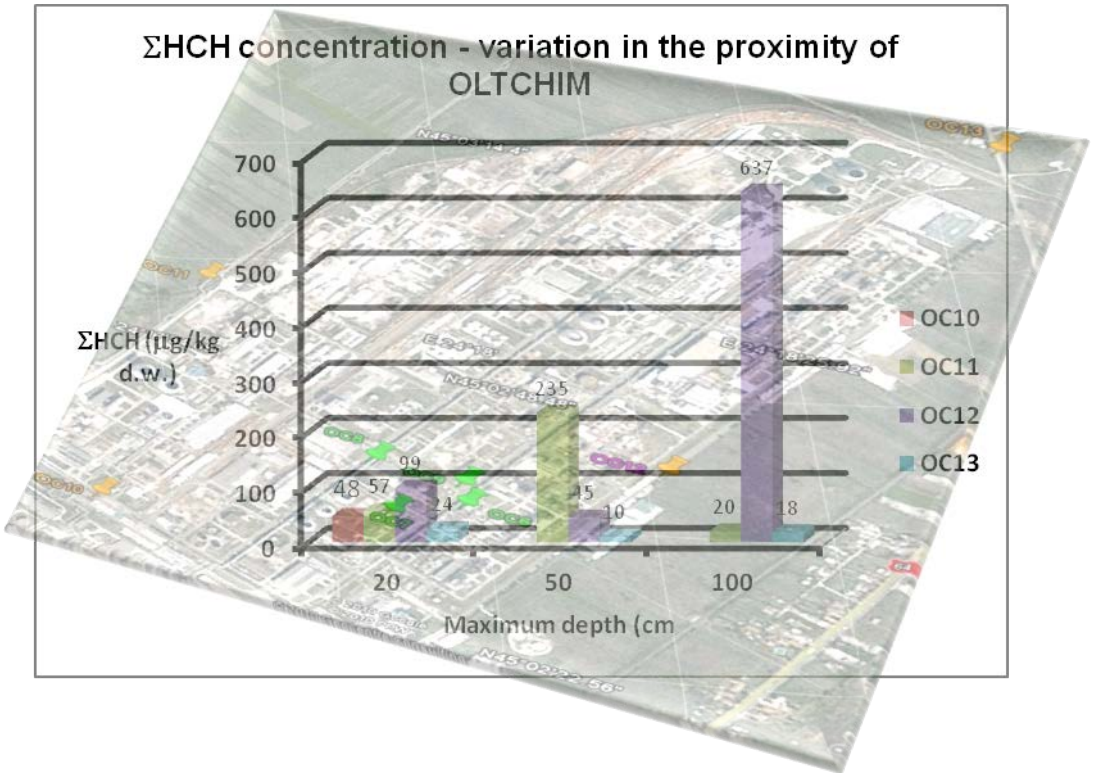

ΣHCH concentration - variation inside Oltchim factory (ex HCH fabrication area)
ΣHCH (µg/kg d.w.)
14000
12000
10000
8000
6000
4000
2000
0
12880
959
510
417
74
277
45
20
30
40
50
100
Maximum depth (cm)
OC6
OC7
OC8
OC9

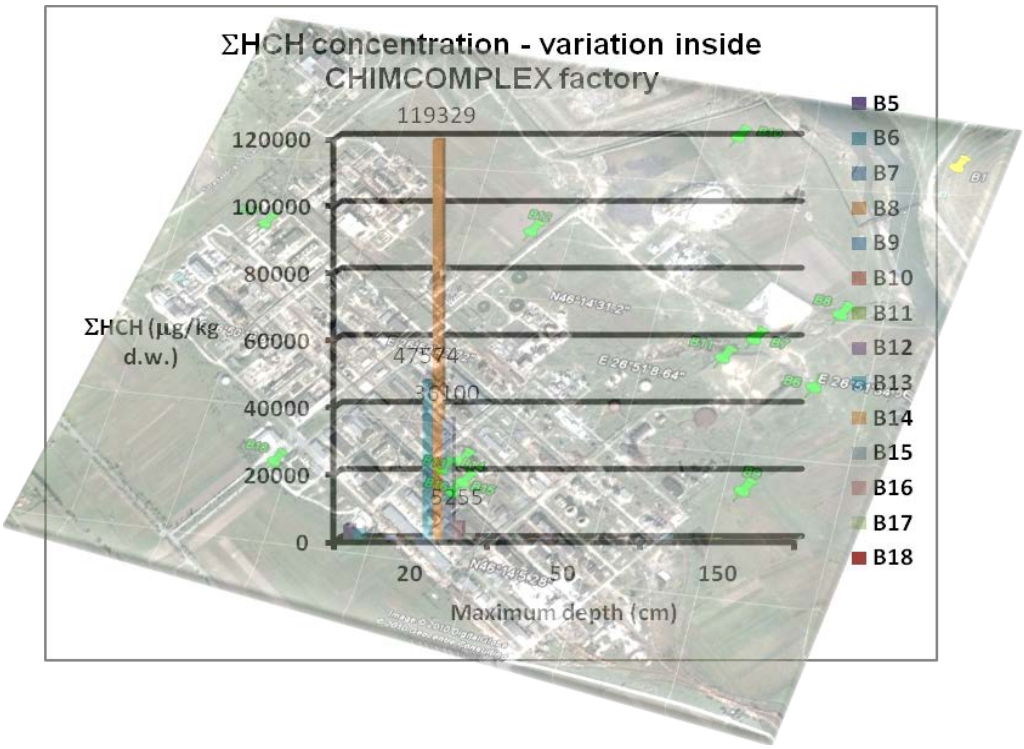
Fig. 4



CHIMCOMPLEX case study – figures 5-8

- Former HCH and DDT installation are the cause for historical pollution in the area of CHIMCOMPLEX factory, concentration levels were over OLTCHIM samples;
- Normal and alert/intervention limits were overtaken in the following sampling points (maximum values):
  - HCH isomers landfill: B6 sample (0-20 cm), 3 mg ΣHCH/kg d.w. (33 µg γHCH/kg d.w.);
  - Organic landfill: B5 sample (0-20 cm), 4,5 mg ΣHCH/kg d.w. (44 µg γHCH/kg d.w.); 1,3 mg ΣDDX/kg d.w. (1 mg DDT/kg d.w.);
  - 2,4 D pesticide installation: B9 sample (0-20 cm), 817,5 µg ΣHCH/kg d.w. (81 µg γHCH/kg d.w.); 84 mg ΣDDX/kg d.w. (74 mg DDT/kg d.w.);

Fig. 5



- Former HCH installation: B14 sample (0-20 cm) 119 mg ΣHCH/kg d.w. (6 mg γHCH/kg d.w.); 136 mg ΣDDX/kg d.w. (131 mg DDT/kg d.w.);
- One single sample, B2 (120-150 cm), outside CHIMCOMPLEX factory (2 km – Viisoara) overtakes alert limit for sensitive uses

Fig. 6

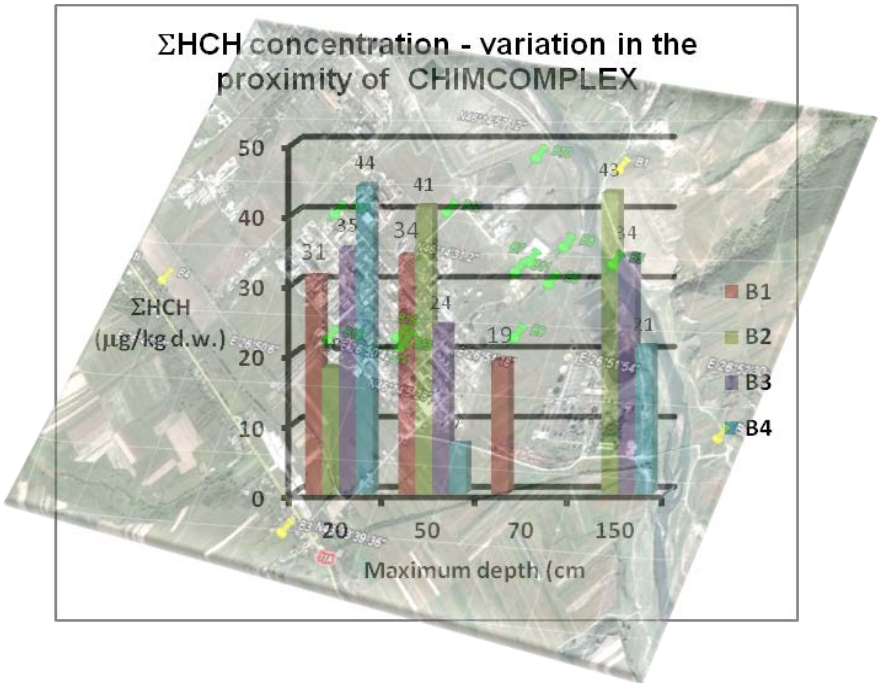


Fig. 7

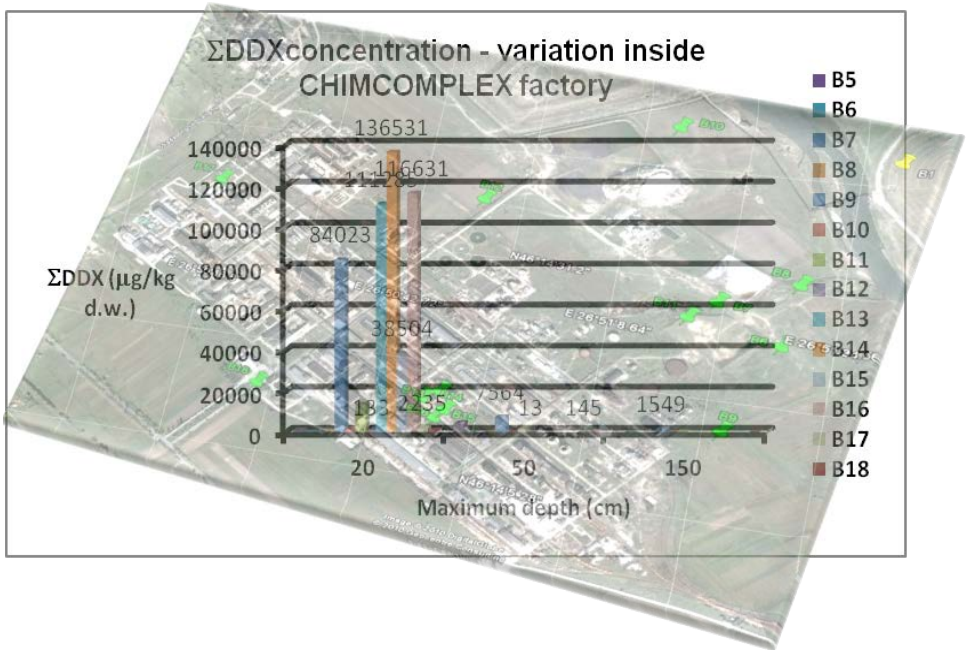
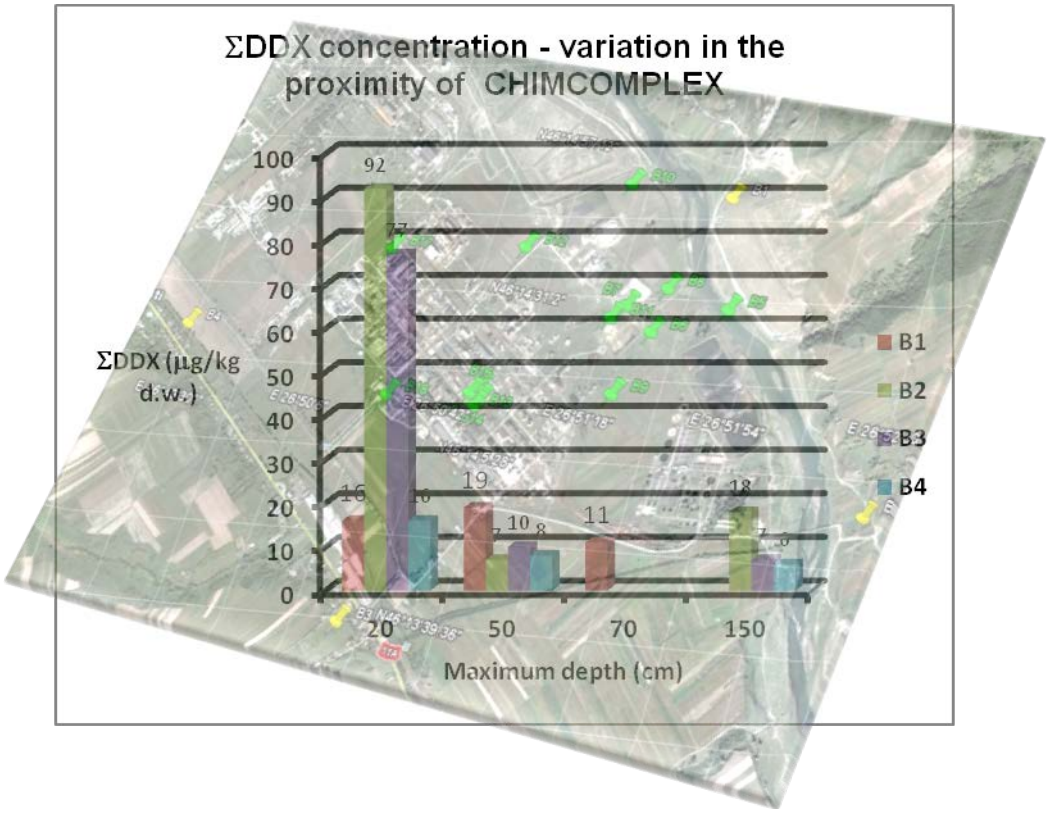

ΣDDXconcentration - variation inside CHIMCOMPLEX factory
ΣDDX (µg/kg d.w.)
Maximum depth (cm)
B5
B6
B7
B8
B9
B10
B11
B12
B13
B14
B15
B16
B17
B18
136531
116631
84023
38504
2235
1549
145
13
0
20
50
150

Fig. 8


ΣDDX concentration - variation in the proximity of CHIMCOMPLEX
ΣDDX (µg/kg d.w.)
Maximum depth (cm)
B1
B2
B3
B4
92
77
19
18
11
10
8
0
20
50
70
150

CONCLUSIONS

- Oltchim samples
  - For all sampling points from **the organic landfill border**, alert/intervention limits were overtaken for at least one depth and at least one HCH isomers;
  - In the **former HCH installation** area alert and intervention limits were overtaken;
- Chimcomplex samples
  - Soil samples from **outside Chimcomplex factory** are generally in the frame of alert and intervention limits for DDX but not for HCH isomers;
  - **Inside the factory**, alert and intervention limits were overtaken for both DDX and HCH isomers.

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