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A PESTICIDE SURVEY IN SOIL, WATER AND FOODSTUFFS FROM CENTRAL ROMANIA

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Abstract: We measured the contamination levels with a broad gamma of pesticides in water, soil and foodstuff from Central Romania. Organochlorine, triazine, carbamate, phenoxy acid and organophosphorus pesticides were analyzed in water, soil and foodstuffs samples. Among the most detected pollutants, we found pesticides prohibited in the European Union, such as isomers of hexachlorocyclohexane (HCHs) and DDT, together with their metabolization products. Detectable concentrations of diazinon (20 ng/l), dichlorvos (20 ng/l) and α-HCH were measured in rivers. Drinking water samples from fountains and tap-water also contained α-HCH (6 ng/L) and γ-HCH (4 ng/L). The DDT and DDE concentrations in soil varied between 20 µg/kg and 50 µg/kg. Concentrations of α-HCH and β-HCH in foodstuffs were 248 µg/kg and 78.3 µg/kg, respectively, both exceeded the Romanian reference value (100 µg/kg for α-HCH and 50 µg/kg for β-HCH). Organochlorines, such as DDT and its metabolization product DDE, were present in almost all foodstuff samples (except for honey), and high values (222 µg/kg for DDT and 35.3 µg/kg for DDE) were measured in eggs.

Key words: DDT, foodstuffs, HCH, Romania, soil, water.

1. INTRODUCTION

Experimental evidence shows a marked correlation between some pesticides as organochlorine pesticides and human carcinogenicity (Ejaz et al., 2004). Cancer of the breast, ovary, prostate, testis, and thyroid were closely associated with occupational and environmental exposure to the so-called endocrine-disrupting pesticides. These pesticides have been classified as carcinogens by the International Agency for Research on Cancer, but only limited studies investigated the possible infestation sources with these pesticides in Romania (Vasilescu, 2000). Romania, like many other developing countries, is confronted with inadequate pesticide safety and hygiene practices. Consequently, millions of people are exposed to these substances each year. Although the use pattern indicates that farm-workers and their families are on the front line of exposed groups, pesticide residues in food and in water demonstrate the potential for non-occupational exposure (Vasilescu, 2000).

Compared to other European countries, only limited research on distribution, occurrence and fate of pesticides has been done in Romania. Most of the Romanian studies published to date have shown a more opportunistic character rather than a systematic approach to chart the pesticide pollution in a specific area.

Some studies presented by investigators from Research Institute for Soil Science and Agrochemistry, Plant Protection Research Institute and the Research Institute for Hygiene and Public Health from Bucharest includes studies performed for several years on condition of the pollutants of organochlorine insecticides (HCH, DDT) that exist in the soils of a few great irrigation systems within the area of the Romanian Plain. Similar studies reported the degrees of pollution with wastes of HCH and DDT existing in waters for irrigation of the respective systems, coming from Danube and from the network of internal rivers (Olt, Arges, Siret) (Blanaru et al. 1996, Fabritius & Balasescu, 1996, Lacatusu et al. 2002).

Selected persistent organochlorine pollutants (POPs), including polychlorinated biphenyls (PCBs) and organochlorine pesticides, such as DDT and hexachlorocyclohexane (HCH) isomers, were shown to be present, sometimes in concentrations higher than Romanian soil limits, in surface soils collected from rural and industrial areas located in the South of Romania (Covaci et al., 2003) and in surface soils and sediments from Eastern Romania (Dragan et al., 2006). DDTs were the main organochlorine pesticides found in these soil samples (concentrations up to 460 ng/g dw), while HCHs were only occasionally found in high concentrations (up to 308 ng/g dw). POPs were also measured in sediments and biota (invertebrates, 11 fish species and cormorant tissues) collected in 2001 from the Danube Delta (Covaci et al., 2006). Also in this case, DDTs were the predominant pollutants in all samples. Human serum samples (n=142) from Eastern Romania collected in 2005 showed also high abundance of DDT and metabolites, together with HCHs (Dirtu et al. 2006). These studies indicate that DDT and metabolites are the predominant organohalogenated pollutants in the Romanian environment and people and therefore special attention should be directed to them.

Approximately 8.000 tones (100% use active ingredients) of pesticides are sprayed annually in Romania onto approximately 15 millions hectares area agricultural land (63% arable land) (Vasilescu, 2000). In spite of the rigorous controls, many prohibited pesticides (DDT, technical HCH – prohibited in Romania since 2003, lindane – forbidden since 2007, are still illegally applied and can be found in relatively high concentrations in Romanian environment, food and humans. Hence, there is a need to assess the nature and degree of the risk and at the same time to take preventive measures aimed at minimizing possible health damages (Hura et al. 1999).

In the present study, we aimed to determine the pesticide residues in soil, water and some foodstuffs in Central parts of Romania and to assess the occurrence in the Romanian environment and food of pesticides prohibited in the European Union.

2. MATERIALS AND METHODS

Samples (n = 57) were collected between November 2004 and April 2005 from different locations in Mures county, Central Romania, with area of 6,714 km², a population of approximately 600,000 and the population density of 86.5 inhabitants per km^2 (Fig. 1).

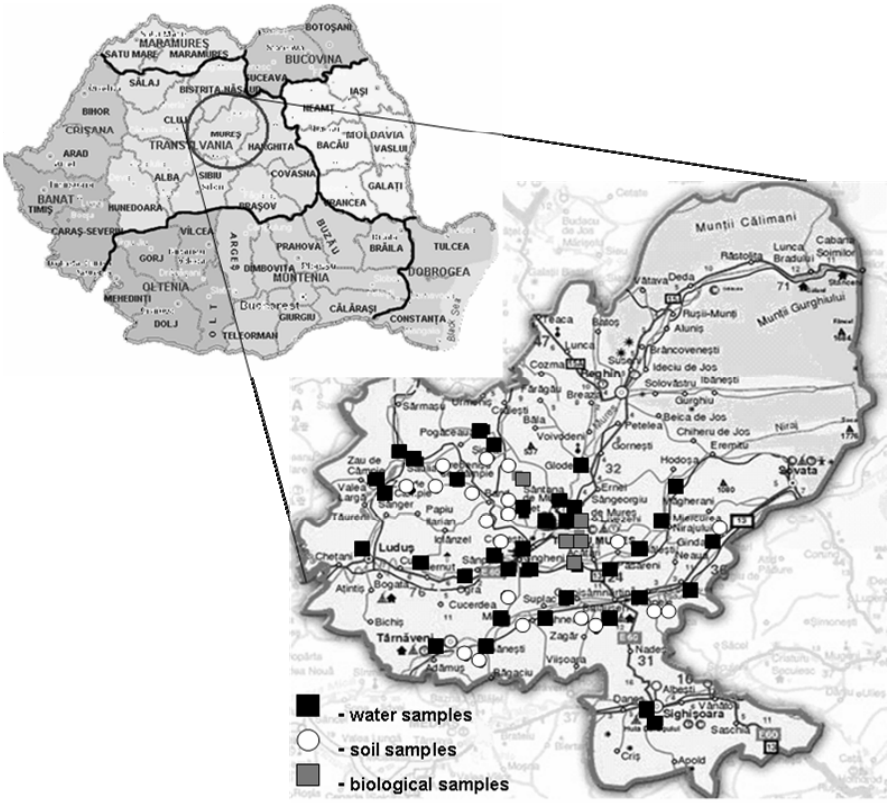

Figure 1. The map of the investigated region

Table 1. The instrumentation and limits of quantification (LOQs) for water soil and foodstuffs samples.

Pesticides	Instrumentation	Limits	Limits	Limits
		Water (ng/L)	Soil (µg/kg)	Foodstuffs (µg/kg)
Organochlorine	EN ISO 6468 (GC-ECD-ECD)	1	10	10
Organophosphorus	EN 12918 (GC-MS)	10	10	10
Triazine	EN ISO 11369 (GC-MS)	10	10	10
Phenoxyacetic acid deriv.	EN ISO 11369 (GC-MS)	10	10	10
Acetanilide deriv.	EN ISO 11369 (GC-MS)	10	10	10
Carbamate	EN ISO 11369 (GC-MS)	10	10	10

Soil samples (n = 20) were collected from agricultural fields,which included apple orchards, vineyards, arable lands (maize, soybean, wheat, potatoes fields), but also greenhouses. Samples were taken from 50 cm deep. Water samples (n = 32) were collected from main rivers (Mures, Tarnava Mare and Tarnava Mica) and their tributaries (Lechinta and Niraj), permanent lakes, temporary lakes after snow melting, but also drinking water sources from fountains and tap-water. Biological samples (n = 5) consisted of 2 composite eggs samples (each composed of 10 chicken eggs acquired from the 2 most important markets in Tg. Mures), honey (n = 1), pork fat (n = 1) and a composite potatoe sample (n = 1).

A number of 1316 measurements were made using gas chromatography with mass spectrometry (MS) and electron-capture detection (GC-ECD). A broad gamma of 70 different pesticide was targeted, from which the following compounds were detected above the limit of quantification (LOQ) during analysis: HCHs, DDTs, dieldrin, diazinon, 2,4-D, atrazine, dichlorvos and Cu^{2+}. The analyses were performed in WESSLING Hungary Ltd (Budapest, Hungary). A Hewlett Packard (HP 6890) gas chromatograph with dual column and two ECD detectors (GC-ECD/ECD) was used for the organohalogen derivatives, and a HP GC coupled to mass spectrometer system (MS 5973) (GC/MS) for other pesticides, while an Perkin Elmer Optima 5300 DV ICP-OES was used for Cu^{2+}. The Environmental Testing Laboratory of WESSLING Hungary Ltd. is certified as an independent testing laboratory, its management system satisfying the requirements of standard MSZ EN ISO/IEC 17025:2005. LOQs for chlorinated compounds, using GC-ECD were 1 ng/L for water samples and 10 µg/kg for soil and food samples, while for triazine, carbamate, phenoxy-acetic acid and organophosphorus pesticides 10 ng/L and 10 µg/kg, respectively (Tab. 1).

For calculation of various physico-chemical parameters, such as water solubility, partition coefficient (log*Kp*), half-life time in soil ($t_{1/2}$), adsorption coefficients (log*Koc*) and bio-concentration factors (log*BFC*) of the most frequently identified pesticides, the EPI Suite 3.12 software were used (EPI, 2000).

Parameters such as: partition coefficient (log*P*), melting point, vapour pressure, water solubility, hydrophobic character, bio-concentration factor (*BCF*) and half-life ($t_{1/2}$) in soil and soil adherences (log*Koc*), Groundwater Ubiquity Score (*GUS*) were calculated for the most detected pesticides to determine their environmentally impact (Tab. 2). This approach is useful for prioritizing pesticides that pose potential health hazards and for which monitoring should be considered.

The *Koc* describes the relative affinity or attraction of the pesticide to soil/media material and, therefore, the pesticide's mobility in soil/media (Uddameri & Kuchanur, 2004). Pesticides with small *Koc* values are more likely to leach than those with high *Koc* values. Water solubility and adsorption to soil/media particles are inversely related for most compounds, with some exceptions. Water solubility > 30 ppm indicates that significant mobility is possible if the *Koc* value is low (< 300-500). Pesticides with solubility > 30 ppm and *Koc* values less than 100 are considered a concern in sandy soil by the EPA (Uddameri & Kuchanur, 2004). Pesticides with solubilities of < 1 ppm are believed to have a higher likelihood of runoff. Likewise, pesticides with high *Koc* values are more likely to run off than leach. Pesticides with *Koc* values > 1,000 have a strong soil/media attachment.

Persistence describes how long a pesticide remains active and it is represented by the half-life, which is the time required for a substance to degrade to one-half of its original concentration. In general, the longer a pesticide persists in the environment, the more likely it is to move from one place to another and be a potential water contaminant.

Table 2. Physico-chemical properties of the most frequently identified insecticides.

Properties	DDT	HCH	Dieldrin	Diazinon	2,4-D	Atrazine	Dichlorvos
Melting point (°C, exp)	108.5	112.5	226-230	62.8	140.5	173	234.1
Vapour pressure (Hgmm, exp)	$1.6 \cdot 10^{-7}$	$3.5 \cdot 10^{-5}$	$3.0 \cdot 10^{-6}$	$3.3 \cdot 10^{-5}$	$8.3 \cdot 10^{-5}$	$2.9 \cdot 10^{-7}$	$1.6 \cdot 10^{-2}$
Water solubility (mg/L, exp)	0.0055	5.5	0.22	--	677	35	8000
Water solubility (mg/L, calc)	0.0073	4.0	0.15	1.1	336	214	1889
Log *Kp*, exp	6.91	4.14	5.30	--	2.81	2.61	1.47
Log *Kp*, calc	6.79	4.26	5.45	4.73	2.62	2.82	0.60
Koc, calc.	220300	3380	10600	12600	29.41	230.4	40.2
log*Koc*	5.343	3.529	4.025	4.100	1.469	2.362	1.604
Evaporation from river ($t_{1/2}$, hour)	134.4	196	116.3	4835	24590	364300	1518
Evaporation from lake. ($t_{1/2}$, hour)	1624	2281	1432	52890	268400	3975000	16680
$t_{1/2}$, soil (day)	2000	400	1000	40	10	60	0.5
GUS	-4.433	1.225	-0.075	-0.160	2.531	2.912	-0.721

According to EPA guidelines (Arnot & Gobas, 2006), the Bioconcentration Factor (*BCF*) is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. In the context of setting exposure criteria, it is generally understood that the terms "*BCF*" and "steady-state *BCF*" are synonymous. A steady-state condition occurs when the organism is exposed for a sufficient length of time that the ratio does not change substantially.

The importance of adsorption and persistence can be illustrated through the Groundwater Ubiquity Score (*GUS*) index (Gustafson, 1993). GUS is calculated using the following simple equation:

$$GUS = \log(t_{1/2}) \cdot (4 - \log Koc) \quad (1)$$

The Groundwater Ubiquity Score, or *GUS*, frequently is used to rate pesticides for their potential to move toward groundwater. The *GUS* is a number that relates pesticide persistence (half-life) and sorption (*Koc*) in soil. A pesticide with a short half-life and high *Koc* will have a lower *GUS* than a pesticide with a long half-life and low sorption coefficient. Pesticides with *GUS* < 0.1 have low mobility in water. Values between 1.0 and 2.0 means medium mobility, while between 2.0 and 4.0 high mobility.

3. RESULTS AND DISCUSSION

In 31 out 57 samples, at least one of the investigated pesticides was present above LOQ (Tab. 3). High concentrations of pesticides were identified in main rivers, in soil samples and in some foodstuffs (Tab. 3). The most common pesticides were hexachlorocyclohexane isomers (α-, β- and γ-HCH), 1,1′-(2,2,2-trichloroethylidene)bis(4-chlorobenzene) (DDT), and its degradation product, 1,1'-(2,2-dichloroethenylidene)bis(4-chlorobenzene) (DDE). Other frequently detected pesticides were: dieldrin [*rel*-(1a*R*,2*R*,2a*S*,3*S*,6*R*,6a*R*,7*S*,7a*S*)-3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphth[2,3-*b*]oxirene], diazinon [*O,O*-diethyl *O*-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl] phosphorothioate], 2,4-D [(2,4-dichlorophenoxy)acetic acid], atrazine [6-chloro-*N*-ethyl-*N*′-(1-methylethyl)-1,3,5-triazine-2,4-diamine] and dichlorvos [2,2-dichloroethenyl dimethyl phosphate] (Tab. 3).

We detected pesticides in 16 water samples. Diazinon (20 ng/l), dichlorvos (20 ng/l) and α-HCH (an average of 5.8 ng/l) were measured in Mures, Niraj, Lechinta, Tarnava Mare and Tarnava Mica rivers. Drinking water samples from fountains and tap-water also contained α-HCH (6 ng/L) and γ-HCH (4 ng/L). The half-life of HCH isomers is relatively high, while 2,4-D and atrazine (with concentration of 110 ng/L) have shorter half-life period, higher water solubility and low adherence to soil particles (Table 2). In one water sample, the concentration of 2,4-D was 100% above the standard criteria for EU (70 ng/L) (Tab. 3).

Similar values as found in the present study were reported for other Romanian rivers, such as the Danube and its tributaries (Bratanova et al., 1998). The most detected pesticides were the HCH isomers, HCB, and DDT, together with atrazine and desethylatrazine. The contamination levels were in the order of 10 ng/L for DDT and 100 ng/L for atrazine (Bratanova et al., 1998).

Table 3. Concentrations of the detected pesticides and Cu^{2+} in Central Romanian water, soil and foodstuffs samples.

Chemicals	Detection[a]	Average	Min.	Max.	Median	SD
Water (ng/L) (n = 16)						
α-HCH *	11	5.8	1	20	4	5.5
β-HCH *	7	2.2	1	4	2	1.1
γ-HCH **	9	2.6	1	4	3	1.3
Atrazin	3	77	30	110	90	42
2,4-D	1	150	-	-	-	-
Cu^{2+}	1	5000	-	-	-	-
Diazinon	1	20	-	-	-	-
Dichlorvos	1	20	-	-	-	-
Soil (µg/kg) (n = 12)						
DDT *	3	30	20	50	20	17
DDE *	2	35	20	50	35	21
Dieldrin	5	34	27	46	33	7
Eggs * (µg/kg) (n = 2)**						
α-HCH *	2	155	61	248	155	132
β-HCH *	2	52.6	26.9	78.3	52.6	36.3
DDT *	2	119	15.7	222	119	146
DDE *	1	35.3	-	-	-	-
Pork fat (µg/kg)						
α-HCH *	1	61.0	-	-	-	-
β-HCH *	1	26.9	-	-	-	-

a - number of samples where the corresponding analyte was detected; SD – Standard deviation;
* - forbidden pesticides in Romania, ** - forbidden from 2007, *** - pooled 10 egg from the same commercial.

Concentrations of HCHs in Danube Delta sediments ranged from 0.9 to 9.0 ng/g dry weight (dw) with a higher contribution of the γ-HCH isomer (range 31-76%), followed by α-HCH (range 24-34%). DDTs were found in sediments at higher concentrations than HCHs and ranged from 0.7 to 33 ng/g dw. The parent compound, p,p'-DDT, were detected only in low concentrations (up to 1.3 ng/g dw) and contributed with less than 18% to the sum of DDTs in sediment (Covaci et al. 2006). Data on the occurrence and levels of pesticide residues in the river Danube and its tributaries collected from 10 Danube riparian countries were also presented (Albanis et al. 1998). Most of the findings relate to organochlorine pesticides (HCH isomers, HCB, and DDT), atrazine and desethylatrazine. Simazine and chlorinated phenols (2,4-dichlorophenol, 2,4,6-trichlorophenol and pentachlorophenol) were also reported. The contamination levels were at the order of 10^{-2} µg/L for both lindane and DDT except for Romania where higher values have been found. The concentrations of atrazine were at the level of 10^{-1} µg/L. The intensive agricultural use in the catchments of these rivers may be future pollution sources and can explain the detection of pesticides along the main Romanian water courses. Well and ground water pollution by triazine and chloroacetanilides were also shown to be highest in the estuarine areas, indicating that many of these compounds are transported significant distances from their application sites (Albanis et al. 1998). The major inputs of atrazine, alachlor, simazine and metolachlor occurred in May and June just after their application. Atrazine, DEA, carbofuran, simazine, diazinon, parathion ethyl and parathion methyl were detected in rainfall water samples collected in the agricultural area. The higher concentrations in underground waters were measured during the period June, following seasonal application and diminished significantly in the fall and winter. The higher concentrations of pesticides detected in underground waters were 0.089 µg/L for alachlor, 0.098 µg/L for atrazine, 0.205 µg/L for desethylatrazine, 0.090 µg/L for carbofuran, 0.041 µg/L for metolachlor, 0.077 µg/L for molinate, 0.018 µg/L for propanil, 0.007 µg/L for parathion methyl and 0.037 µg/L for simazine (Albanis et al. 1998).

Comparing these results with our data outcomes that these high concentrations of prohibited pesticides can be explained with the extensive and nevertheless illegal use in Central Romanian agricultural fields.

According to our assessment pesticide residues were detected in 12 out of 20 soil samples. The DDT and DDE concentration in soil varied between 50 µg/kg (apple orchards) and 20 µg/kg (arable agricultural fields). Because our samples were collected from 50 cm deep it is probable that soil surface can have even higher concentrations. The detection of DDT suggests that it may still be

used in Romania.

In similar studies DDT concentrations in surface soil from agricultural land were significantly higher at rural sites and only few samples (three out of 48) exceeded the official European norms (Covaci et al., 2003). The relatively high p,p'-DDT may prove the presence of an aged DDT mixture. Samples from individual farms, located in areas where pesticides were not used or used only sporadically, showed concentrations below LOQ. The detection of DDT by other authors can be attributed to the more recent use in Romanian agriculture compared with Western Europe (DDT was banned in 1985 in Romania) and to a very slow degradability with a half-life in soil of 2000 days (Dragan et al. 2006). The HCHs for soil samples were under LOQ in concordance with other similar studies that reporting much lower concentrations in the Western and Eastern part of Romania compared to the South. This shows the use for certain agricultural purposes of HCH mixtures in parallel with the DDT mixture. Moreover, the distribution of HCH isomers indicated a mixed use of technical HCHs versus pure lindane (Covaci et al., 2003). Similar studies detailed the organochlorines in the forested zones in all soil samples from eight Eastern Romanian counties. The concentrations of OCPs were in the following range: 0.2–1.4, 5–56, and 5–95 ng/g of soil for HCB, sum HCHs, and sum DDTs, respectively. Two samples containing higher concentrations of HCHs and DDTs collected from Bacau county. The γ-HCH isomer was predominant (54–74%), followed by *β*- and α-HCH isomers (8–22 and 18–28%, respectively). This sample exceeded the Romanian permitted value (50 ng/g of soil) for *β*-HCH in agricultural soil (Dragan et al. 2006). In Romania, two HCH formulations were used in the past: technical lindane, containing 60–70% *γ*-HCH, 5–12% *γ*-HCH and 10–12% *γ*-HCH, and pure *γ*-HCH (lindane). Only *γ*-HCH is insecticidal, while *β*-HCH is more bio-accumulative. Moreover the physico-chemical properties of the α-HCH indicate a greater affinity for atmospheric transport than other isomers.

All these results suggest the usage of pure lindane rather than technical lindane and thereby a predominant contamination through atmospheric deposition of isomers volatilized from treated agricultural soils. According to our studies dieldrin was detected in soil samples, especially in agricultural lands (Tab. 3). Dieldrin are highly persistent insecticide, in similar studies were detected in soil 15 years after its application (Morrison et al., 2000). Therefore the presence in soil can not be directly attributed to actual use. Moreover many organisms, especially agricultural pests (fruit flies, aphids and mites) are resistant to Dieldrine. In comparative studies dieldrin was no longer toxic to these insects at 120 d. These results shows that dieldrine residing in soil become less toxic with time, the extent of decline in bioavailability may differ among different species, and vigorous extraction may grossly overestimate toxicity (Robertson & Alexander, 1998).

The concentrations of α-HCH and β-HCH in eggs were 248 and 78.3 μg/kg respectively, both exceeded the Romanian reference value (100 μg/kg for α-HCH and 50 μg/kg for β-HCH) (Fig. 2). HCHs were detected also in pork fat (61 and 26.9 μg/kg for α-HCH and β-HCH, respectively).

This is in agreement with the detection of HCHs in Romanian foodstuffs reported by other authors. HCH-total was detectable in food (milk, bread, diets, coffee), as well as in pork organs collected from Romanian farms (Covaci et al., 2004). Animal fat samples showed high concentrations of HCHs, but only two samples (out of 24) exceeded the EU norms (1000 ng/g fat) (Covaci et al., 2001). Organochlorines, such as DDT and its degradation product DDE, were present in the egg samples in high values (222 μg/kg for DDT and 35.3 μg/kg for DDE).

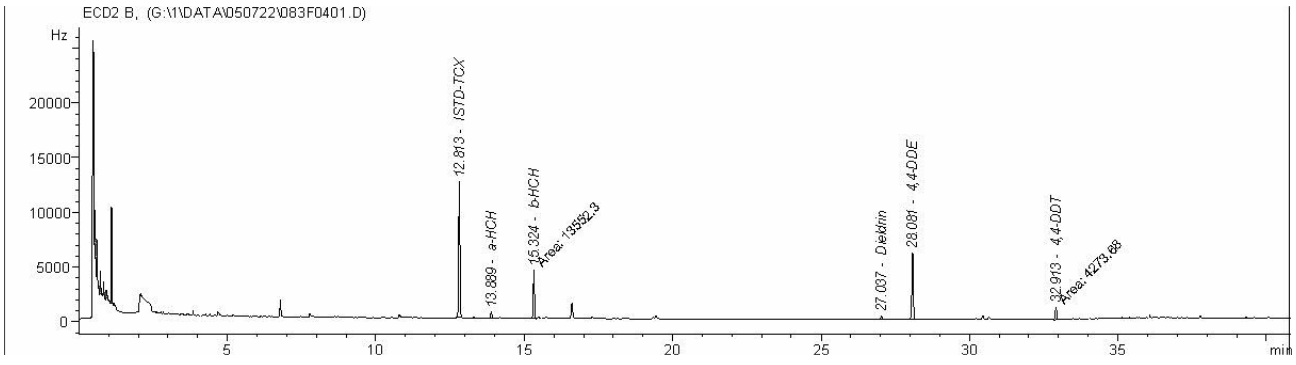

Figure 2. The chromatogram of egg samples.

In both egg samples, the concentration of DDTs was above the EU maximum level of 50µg/kg for sum DDT in foodstuffs (Tab. 3). DDT has a high half-life time and persistence in the environment long after its initial application as an insecticide (up to 12 years). During this time, DDT and its breakdown products may enter the food chain and accumulate in fatty tissues of the human and animal bodies therefore diet is the most important route for organochlorine pesticides (bioaccumulation) (Felsot et al., 2003).

Despite the existing regulatory framework, undesirable amounts of banned pesticides can still be found in agricultural products from Romania, but also in human body (placenta, milk, urine) hair and young body (serum, urine) (Covaci et al., 2001, 2002, 2004). HCHs were found in more than 98% of the investigated human populations from Iasi, Romania and β-HCH was the most prevalent HCH isomer with a median value of 923 ng/g lw. The DDT analogues (p,p′-DDE, o,p′- DDT and p,p′-DDT) were measured in all human serum samples. The major contributor (> 70%) to the sum DDT was p,p′-DDE which was found at a median value of 1975 ng/g lw with a range between 340 and 24,280 ng/g lw. The levels of p,p′-DDE were significantly higher in individuals with a rural main residence and concentrations of most pollutants correlated significantly with age (Dirtu et al. 2006).

4. CONCLUSIONS

Persistent organic pollutants (POPs), and pesticides in particular, represent an issue of concern in Romania both for the environment and public health protection. Major problems include:

1. An absence of correct and systematic information on persistent organic pollutants, and no awareness regarding the danger on human and environmental health;
2. There is no inventory of national pollution sources for POPs;
3. Only the global figures of pesticide active ingredients (tonnes/year) are reported;
4. There is no systematic control of food production and consumption on the internal market;
5. There are no systematic studies to identify the human and environmental burden with POPs and the links between them (Vasilescu 1994, 2003).

The DDT has been prohibited in Romania in the 1980's, it may be illegally used in rural areas. Although there is currently no direct link between DDT and any negative human health effect, there is growing evidence that it may disrupt reproductive and endocrine functions (Ejaz et al., 2004). Advocates of the continuing use of DDT as an insecticide for disease vector control base their argument on various factors: the unacceptably high levels of mortality and morbidity caused by malaria, the proven effectiveness of DDT in significantly reducing malaria transmission, the relatively low cost of DDT interventions, and the lack of any sustainable alternative in many endemic countries (Edwards, 2004), but this in definitely not the case in Romania. Pesticides as HCHs, 2,4-D and Antrazine can also induce carcinogenity and hormonal dysfunction in human organism; therefore these were classified in different categories by IARC and U.S. EPA relating to their risk. Especially HCH and Antrazine are known as inducing hormonal dysfunction (Allen et al. 2008). A comprehensive monitoring scheme is therefore needed through more financial investment and commitment. An investigation system for the evaluation of risks and coordination of monitoring systems, as well as building a database, is necessary in Romania to be able to correlate causes and effects when dangerous exposures are identified.

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