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MONITORING OF MERCURY FROM AIR AND URBAN DUST IN THE INDUSTRIAL AREA OF IASI MUNICIPALITY

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Abstract

The present work is dealing with the identification of the mercury sources and the quantification of the mercury level in air and urban dust in the industrial area of Iasi municipality. A correlation between some meteorological indicators, atmospheric mercury content and the urban dust from the investigated area was pointed out, based on the real time measurements as well as spatial distribution of other heavy metals in urban dust.

The measurements of mercury level in air were carried out at the five monitoring sites for 14 days in each month during the time period of November-December 2012, twice per day. Also, thirty-six roadway dust sampling sites were selected for investigation in the industrial area of Iasi city, comprising different types of pollution sources from transportation traffic with low and high density, as well as from industrial, residential and commercial areas. After statistical processing of data, two clusters have been noticed for gaseous elemental mercury present in the atmosphere: one with values between $10 - 21.37$ ng/m^3 due to heavy traffic and industrial activities (natural gas power plant, metallurgical producers, plastics manufactures), and another ranging between $4.3 - 14.5$ ng/m^3 generated by fuel combustion. Mercury concentration in roadway dust ranges between 0.18-0.70 mg/kg with an average of 0.48 mg/kg.

Key words: air pollution, gaseous elementary mercury, geochemical distribution, geographic information system, heavy metals

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1. Introduction

Mercury is a popular chemical with high toxicity, without any relevant characteristics that could allow its detection by human sensing receptors, under typical urban conditions. Instead, its harmful effects on human health are highly visible, which can explain the local, regional and international concern on this compound and the increased governmental interest in mercury monitoring (Pirrone, 2008; Pirrone et al., 2013).

The amount of mercury mobilized and released into the environment has increased with the industrial age (Mason et al., 1994). Mercury pollution in urban area is primarily due to human activities. Mercury emissions generated by the human activities were ranged between 60% and 90% from total mercury content determined in some industrialized regions (Nriagu, 1989).

Once emitted into the atmosphere, elemental mercury may be transformed to oxidized compounds that are readily deposited by dry and wet processes to land and aquatic surfaces; moreover, it is well known that urban dust has adverse health effects, being related to respiratory diseases. In Europe, the typical concentrations of mercury in ambient air may reach up to 2.5 ng/m^3, but in some urban areas the values are usually higher, ranging between 5 to 15 ng/m^3 or

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even higher in several cases (EMEP, 1999; EC-WGM, 2001). Anthropogenic sources responsible for heavy metal contamination of various environmental compartments are mostly transportation, mining, smelting, refining, waste incineration, and fossil fuel combustion (Bem et al., 2003; Lu et al., 2009; Ma et al., 2013; Ozaki et al., 2004; Tasdemir and Kural, 2005). Key heavy metals are lead, mercury and arsenic from leaded gasoline, Cu, Zn and Cd from car components, tire abrasion, lubricants and industrial and incinerator emissions. Reports show for gasoline a mercury content of 0.2–3.3 ng/g (Liang et al., 1996). Coal burning is considered as one of the major sources of anthropogenic trace metals inputs in the atmosphere (Zereini et al., 2005).

Fine particulates of <10 μm aerodynamic diameter represents the main fraction of aerosols discharged from the precipitators of the coal fired thermal power plants (Sandelin et al., 2001). The long-term input of mercury to environment can result in both surface and groundwater contamination as well as decreased buffering capacity of the soil. Also the increased mercury contents in the environmental compartments can have negative effects on human health upon repeated exposure (Brinkmann, 1994). Children in particular are more susceptible to the negative health effects of metals due to their small body size, and their developing nervous system.

The atmospheric pollution is one of the major causes of metal contamination in roadway dust (Iordache and Dunea, 2013). The chemical components and quantities of roadway dust in urban centers are important environmental pollution indicators (Yongming et al., 2006). Thus numerous studies have been focused on several subjects as the level of heavy metal contamination in roadway dust and source identification. Most of the studied areas in terms of soil contamination evaluation by mercury emissions were located in rural environments (Gustin et al., 2002, 2006) and just a few studies were carried out in urban environments (Bhakta and Munekage, 2010; Gabriel et al., 2005, 2006; Kim and Kim, 1999). The results from the urban studies suggest that mercury emissions may be high compared to undisturbed natural areas, and may also have large variability over space and time.

The objectives of this study are: to identify the mercury sources and to quantify the mercury level in air and urban dust corresponding to the sources found in the industrial area of Iasi municipality. Also, the correlation between the meteorological indicators, atmospheric mercury content and the urban dust in the investigated area will be pointed out, based on the real time measurements as well as spatial distribution of other heavy metals in urban dust.

2. Material and methods

2.1. Background of study area

Located in North Eastern Romania (47°12′-47°05′N, 27°27′- 27°39′E), the Iasi municipality was

documentary attested since the XV century. It has about 93.9 km², with the urban population of approximately 290422 in 2011, being the fourth largest city in Romania. During the communist period, the city experienced a rapid industrialization followed by a process of urbanization, becoming an industrial center, especially developed in the chemical industry, ferrous metallurgy, machine building, textile, thermal energy production, ceramic, electronics, food processing and medicines.

Most companies were located in the eastern part of the city in the Bahlui river floodplain that was raised by about 8 m, forming the so-called "industrial area". The study area, including residential, industrial and transportation traffic zone categories, was situated on an urbic entiantrosol (ETur) with pH from 7.1-8.5 (Secu et al., 2008). The Iasi city, from a geological point of view, belongs to the Moldavian Platform (Apostoae et al., 2007), which, according to Ionesi (1994), is made of a bedrock basement (which was reached at depth of 1121 m in Iasi) and a sedimentary cover (deposits belonging to the Upper Vendian, Palaeozoic, Cretaceous, Palaeocene, Eocene, Upper Badenian, Sarmatian and Meotian periods), at which the Quaternary deposits are added. Urban dust mineralogy (Curca, 2011) reveals mainly the presence of quartzite (75%), carbonates (10%) and feldspar (5%).

The climate has a pronounced continental character, influenced by eastern air masses with cold winters and hot summers. The high amplitude of temperature oscillations throughout the year are mainly due to variation of the angle of incidence (47°) of sunlight with topography. The inter - diurnal rise of the average temperature are more emphasized in winter as well as the temperature inversions while during the summer months temperature inversions are characterized by the lowest intensity, frequency and vertical extension. General orientation of the relief from north-west to south-east favors the air mass movement in this direction, generating a dynamic daily atmosphere represented by hill-valley breeze in the morning and night and by the valley-hill breeze at noon and afternoon. The most frequent winds are from NW (22%), E (15%) and W (10%) directions (Alexe, 2012). The wind direction is influenced by the complexity of the active surface (streets, buildings, parks) leading to the diminishing of the average wind speed down to 2-4 m/s. The annual rainfall regime is continental, between 500-600 mm.

Study area of 5.6 km² is a major transit point situated in the eastern part of the town. It is an industrial area subject to potential pollution exposure due to high intensity of ruttier traffic, but also due to the locations of the above industrial companies classified according to their activity as: the power plant based on natural gas, paints, metallurgical producers, plastics manufactures, producers of different building materials (ceramics, cement, bitumen, and concretes), and waste water treatment plant. Nowadays, this area is in the changing process

due to the adjustment of each company profile in concordance with the market requirements recently studied by Lacatusu et al. (2007, 2008).

Anthropogenic emissions of dust in this area are generated by traffic (nonskid dust), constructions, streets rehabilitation or emissions from industrial agents. Nonskid dust used in the cold season is the main source of particulate matter in the city.

2.2. Sampling

Thirty-six roadway dust sampling sites were selected for investigation in the industrial area of Iasi city, which includes waste water treatment plant and different types of pollution sources: transportation traffic with low and high density, industrial, residential, commercial (Fig. 1). The area has been divided in a rectangular network, with 0.5/0.6 km dimension, resulting 36 polygons. The roadway dust composite sample of 100 g was collected as possible across all representative area, according to a random sampling scheme. The sampling plan was developed taking into account the most relevant characteristics of the environment during the dry period in December 2012.

The sampling was carried out by sweeping of dust with a polyethylene brush and then the collected dust was kept in zip plastic bags, labeled and transported to the laboratory. Samples were then divided in two subsamples: one for immediate mercury analysis and other for heavy metals analysis. The samples were stored in the freezer to avoid mercury volatilization and then sieved through a 1.0 mm mesh nylon sieve to remove refuse and small stones before halving. Duplicate samples were used in the analysis process, with a standard deviation less than 5%. All handling was carried out without contact with metals, to prevent cross-contamination.

The measurements of mercury level in air were carried out at the five monitoring sites for 14 days in each month during the time period of November-December 2012, at two times: in the morning (8-9 AM) and at noon (1-2 PM). Locations of air monitoring have the following correspondence with urban dust sampling: S1=2 – traffic intersection; S2=5 – parking lot; S3=6 – power plant; S4=10 – heavy traffic intersection and reconverted an industrial complex; S5=15 – traffic and industrial activity.
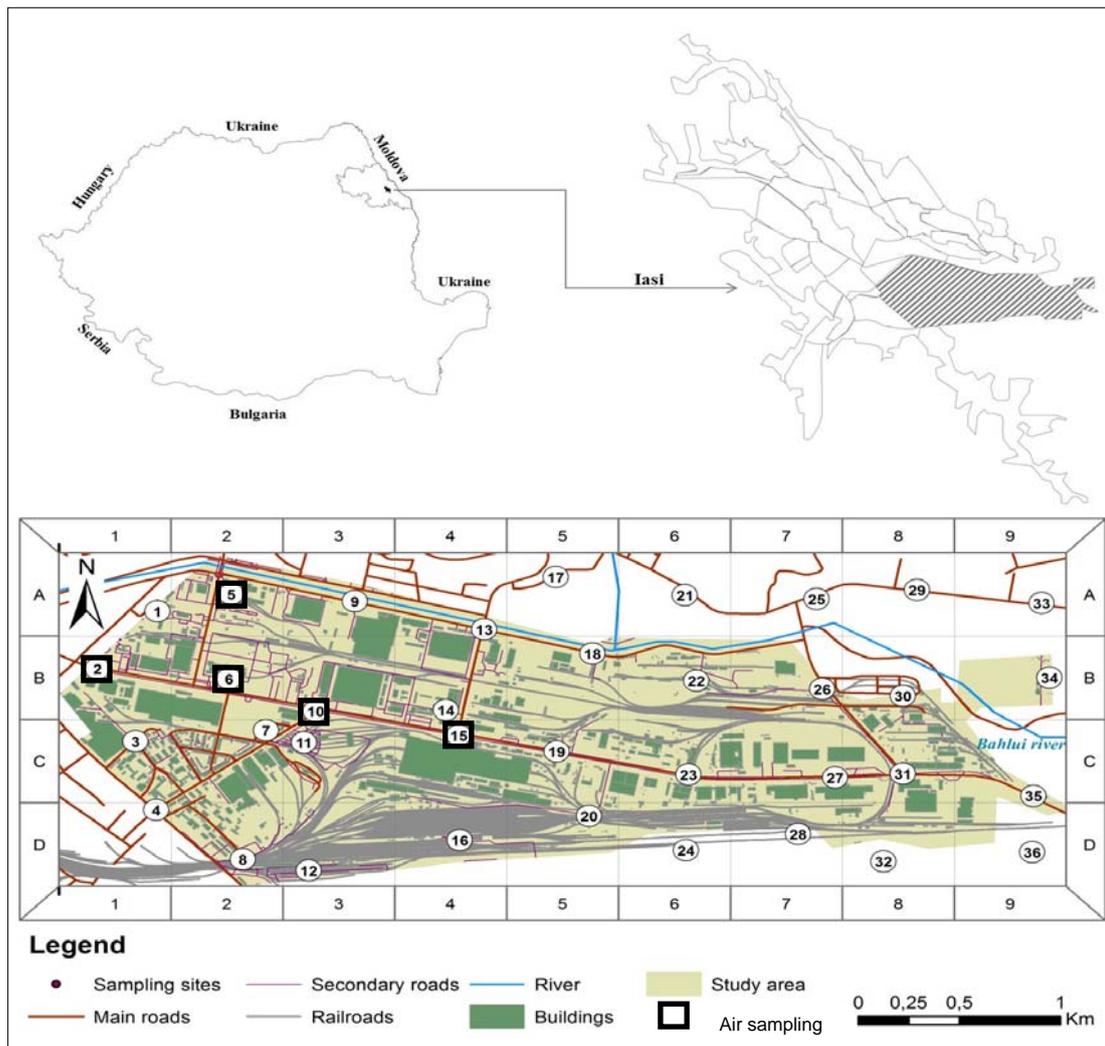
Fig. 1. Study area and sampling sites in Iasi, Romania

3. Experimental

3.1. Measurements of elemental mercury and other heavy metals in dust and air – analytical procedure

There are different chemical methods for mercury and heavy metals analysis (Csuros, 2002; Sibiescu et al., 2010), but the instrumental analysis methods are more rapid and convenient, especially in the field experiments. So, the mercury was determined using a combination of RA 915+ and RP-91C Mercury Analyzer, which is based on the Zeeman Atomic Absorption Spectrometry and High Frequency Modulated Light Polarization (Fig. 2) in accordance with EPA Method 7473.

About 5 to 10 mg of the dust subsamples for mercury analysis were first decomposed and atomized in a pyrolytic furnace RP-91C, followed by the mercury concentration determined by atomic absorption spectroscopy in a RA-915+ analyzer.

The working principle of RA 915+ instrument is based on differential Zeeman atomic absorption spectrometry with high modulation of light polarization. By adding the RP-91C extension, mercury analysis from the dust samples can be made by converting mercury from a bound state to the atomic state through thermal decomposition at $700^{o}C$. Analytical process involves two stages, first the sample was vaporized, the mercury compounds being partly decomposed, followed by heating up to $800^{o}C$, to total decomposition of both mercury compounds and other organic compounds (Klavins et al., 2011). Mercury concentration is obtained by applying a calibration coefficient, determined based on reference standard, no additional sample

preparation needed, the analysis time being 1-3 minutes per sample (EPA, 2004). Monitoring of elemental mercury concentration was achieved in continuous regime, by air pumping through the multi-path analytical cell of the RA 915+ analyzer at a flow rate of 25 L/min. The detection limit ranges between 1.5-2 ng/m^3, with a response time of 1 s, while the response time increases up to 30 s when the detection limit decreases down to 0.3 ng/m^3 (Wang et al., 2007). Calibration of the instrument and in-run validation were performed using SRM standard reference material NIST 1633b Coal Fly Ash, which were used systematically to check signal accuracy during testing; detection limits were 0.58 ng Hg/g, dw, respectively. In-run SRM validation measurements were consistently within the range specified (Parsons et al., 2007). For air measurements the analyzer can be automatically recalibrated by internal mechanical devices, in order to assure the equipment reliability, precision and accuracy of measurements (Sholupov et al., 2004).

The heavy metal ions were analyzed using atomic absorption spectrometry in air acetylene flames in the hydrochloric solution obtained after $HClO_4$ and HNO_3 digestion.

In order to analyze the physico-chemical effects of mercury distribution, some relevant meteorological data were collected from the weather station Velleman WS 1080 such as: wind speed, wind direction, air temperature, and relative humidity, as well as some main air pollutants such as SO_2, NO_2, NO, PM10, O_3 from IS3- Oancea-Tatarasi, Air quality monitoring network in Iasi - industrial station type, operated by Iasi Environmental Protection Agency (Luca and Ioan, 2012).
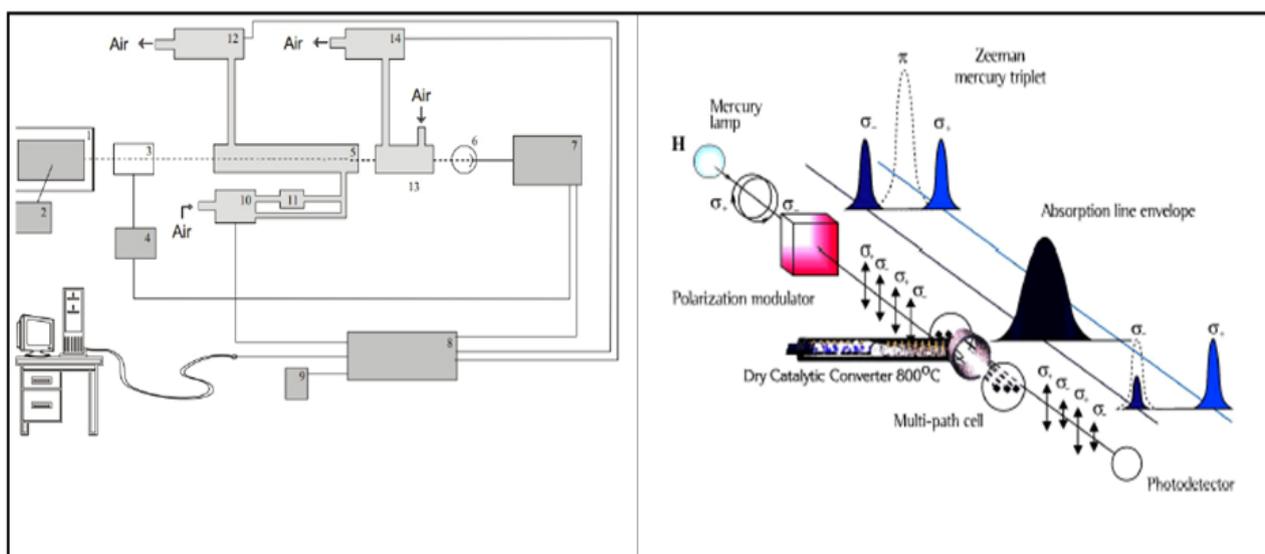
Fig. 2. Functional diagram of mercury analyzer RA 915+ (adapted from RA 915+ instruction manual) 1) mercury EDL lamp; 2) high-frequency generator; 3) polarization modulator; 4) modulator control unit; 5) multi-path cell; 6) photo-detector; 7) electronic signal-processing unit; 8) built-in microprocessor; 9) display and control unit;10) gas flow commutation unit; 11) absorption filter; 12) air pump of the multi-path cell; 13) single-path cell or external cell (part of the RP-91C attachment); 14) air pump of the single-path cell

3.2. Data analysis

To summarize all data collected in the frame of this study, a general descriptive statistics, as well as geostatistical methods were involved. Currently, there are various prediction techniques of spatial variations of the soil properties based on the geostatistical methods. The inverse distance weighted (IDW) method for interpolation was performed using the ArcGIS 10.1 for Windows software, in order to estimate both the heavy metals content in the unanalyzed areas and the pollution pattern determined by different pollution source.

4. Results and discussions

4.1. Mercury in the air

The mercury level in the atmospheric air is modified due to the exchange of mercury quantity between soil and air, which is strongly correlated with meteorological parameters (Nair et al., 2012). Table 1 summarizes the descriptive statistics of gaseous elementary mercury (GEM) concentrations, meteorological parameters and other air pollutants. The average concentration of mercury as GEM was in the range 11.24 ± 4.04 and 12.46 ± 3.77 ng/m^3, higher than the blank site situated in a protected area, without traffic and other activities (2.07 ± 1.63 ng/m^3).

As shown in Fig. 3 concentrations of all samples varied depending on the time of day of analysis (morning and noon) and specific microclimate conditions and the movement of air masses (Llanos et al., 2011).

The differences between monthly GEM concentrations were noticed, mercury concentrations being divided in two clusters: one with values between $10 – 21.37$ ng/m^3 corresponding to the S3-S5 samples.

Table 1. Summary statistics for meteorological data and several air pollutants in Iasi city

Parameters		November 2012-M (n=42)	November 2012-N (n=42)	December 2012-M (n=45)	December 2012-M (n=45)
Temperature(C)					
Min		0	1	-9	-5
Max		7	8	9	8
Mean±SD		3.28±1.96	4.97±2.12	(-)0.61±4.15	0.4±3.31
Relative humidity (%)					
Min		70	61	74	54
Max		100	93	100	100
Mean±SD		92±6.66	84.30±7.98	90±6.81	82.76±12.36
Wind speed (ms^{-1})					
Min		3	9	3	9
Max		12	19	15	38
Mean±SD		6±2.96	12.53±3.83	9±3.21	19.06±6.61
SO$_2$ (µg/m³)					
Min		1.24	1.8	2.5	4.6
Max		7.13	6.84	6	12
Mean±SD		4.06±1.43	4.07±4.21	3.76±0.96	7.29±1.93
NO$_2$ (µg/m³)					
Min		14.01	14.61	18	9
Max		52.16	41.11	90	41
Mean±SD		28.02±11.29	20.32±5.86	37.3±17.43	20.16±10.01
NO (µg/m³)					
Min		15.4	18.51		
Max		130.25	40.96	NO DATA	
Mean±SD		42.81±30.60	25.87±5.57		
PM10 (µg/m³)					
Min		11.79	16.23	0	0
Max		41.16	30.89	63	69.3
Mean±SD		21.96±6.83	23.20±4.97	20.18±15.50	22.2±17.05
O$_3$ (µg/m³)					
Min		2.53	19.76	14.15	24.27
Max		28.21	50.28	35.7	59.74
Mean±SD		20.18±7.49	29.96±7.40	24.56±6.25	40.31±9.93
Hg (GEM) (air) ng/m³		(n=75)			
Min		4.05	3.47	4.86	4.16
Max		19.08	21.37	18.77	20.71
Mean		12.29	12.46	12.12	11.24
St dev.		3.77	4.84	3.37	4.04
Kurtosis		-0.73	-0.90	-0.71	-0.35
Skewness		-0.37	-0.06	-0.19	0.46
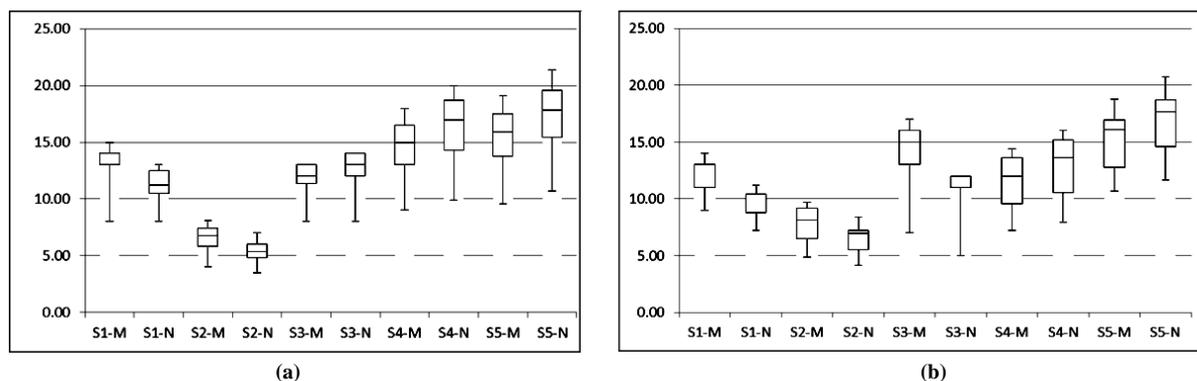
Fig. 3. Box and whisker plot of mercury content in the air of the industrial area of Iasi in November 2012 (a) and December 2012 (b) in the morning and at noon (*ng/m³*). The whiskers represent a confidence interval between 10% and 95%.

This is caused mainly by heavy traffic and industrial activities (natural gas power plant, metallurgical producers, plastics manufactures), the other S1-S2 ranging between 4.3 – 14.5 ng/m³ due mainly to fuel combustion. There has been observed (Fig. 4) a strong correlation between wind characteristics (speed, direction) and mercury emission rate from different sources, suggesting that dominant wind direction facilitates mercury evaporation and its dispersion in atmospheric air (Cretescu and Soreanu, 2013).

In November the predominant wind was from ESE in the morning and E at noon, positively correlated with GEM concentration excepting the areas such as parking lots (S2), suggesting that the stronger anthropogenic emission sources are located in east of industrial area. The lower temperature among with atmospheric pressure from December determined the changes in air masses movement, the predominant wind being from W in the morning and WNW at noon, favoring a more pronounced dispersion of GEM, evidenced by lower values obtained, excepting monitoring site S3, located near a power plants based on gas, that operates at high yields in that period. Some authors (Corbett-Hains et al., 2012) observed the mercury flux from sub-zero temperature soil corresponding to different moisture contents and shown that soil warming from sub-zero temperatures produced mercury flux spikes through a physical mechanism of expansion and contraction of soil during freeze-thaw cycle.

Combustion gases from traffic as well as mercury content from urban dust also contribute to the presence of mercury vapors in urban atmosphere. The priority pollutants, including PM10 (Fig. 5), from the study area present the same behavior as GEM, with higher concentrations at noon, due to the intensification of industrial activities and heavy traffic.

4.2. Mercury and heavy metals in urban dust

The concentrations of Hg, Cd, Co, Cr, Ni, Pb, Cu, Zn, Mn and Fe from urban dust are presented in Table 2. The mean value of Zn (366.51±459.15), Pb (52.96±30.72), Ni (30.67±11.12), Cu (51.41±20.87)

and Hg (0.48±0.13) exceed the normal value from order the 756 /1997, while Zn and Pb are higher than the alert threshold for a sensitive use of soil. The maximum allowable limits after Kloke (1980) was over just for Zn. The highest content of Zn is up to 1922.22 mg /kg in three monitoring sites located in the proximity of the power plant and the commercial complex Carrefour – Felicia (S10 – 1922.22 mg /kg), of S.C. Group Omega Tehnoton, S.A (S23- 1343.92 mg /kg) and waste water treatment plant (S34 – 1614.94 mg /kg) (Wei and Yang, 2010). Increased contents of heavy metals were detected along the main traffic route (Douay et al., 2007).

Mercury concentration in roadway dust ranges between 0.18-0.7 mg/kg with an average of 0.48 mg/kg which are distributed by traffic type: on the roads between 0.18-0.68 mg/kg, in the parking lots 0.31-0.63 mg/kg and in the power plant and waste water treatment plant area 0.48-0.7 mg/kg. The mercury concentration is higher than the mercury normal value but lower than ATs or maximum allowable limits. Higher mercury concentration were recorded in urban dust samples from near power plant (sample 6), waste water treatment plant (sample 34) and heavy traffic sites (10, 11, 14, 15, 18. 31, 33).

The spatial distribution of mercury and other heavy metals in industrial area of Iasi city was made using ArcGIS tools. The geochemical maps were generated by IDW interpolation method (Iancu and Buzgar, 2008). The results of the Hg, Cd, Cu, Co, Cr, Ni, Pb, Zn, Mn, Fe were shown in Fig. 7. The lightly colors indicate an overlap of increased metal level of concentration. Zinc, cuprum, lead, and mercury in the dust may originate from anthropogenic inputs, mostly from traffic emissions and other human activities as former heavy industry. The spatial distribution of Co, Ni, Cr, Mn and Fe was different from other trace metals, which can be attributed to geogenic background or other natural sources, the area being a flooded area with a phreatic level near to surface.

Correlation between the trace metals measured are presented in Table 3. High correlation between metals was expected if considering traffic with daily variation as main sources of contamination.
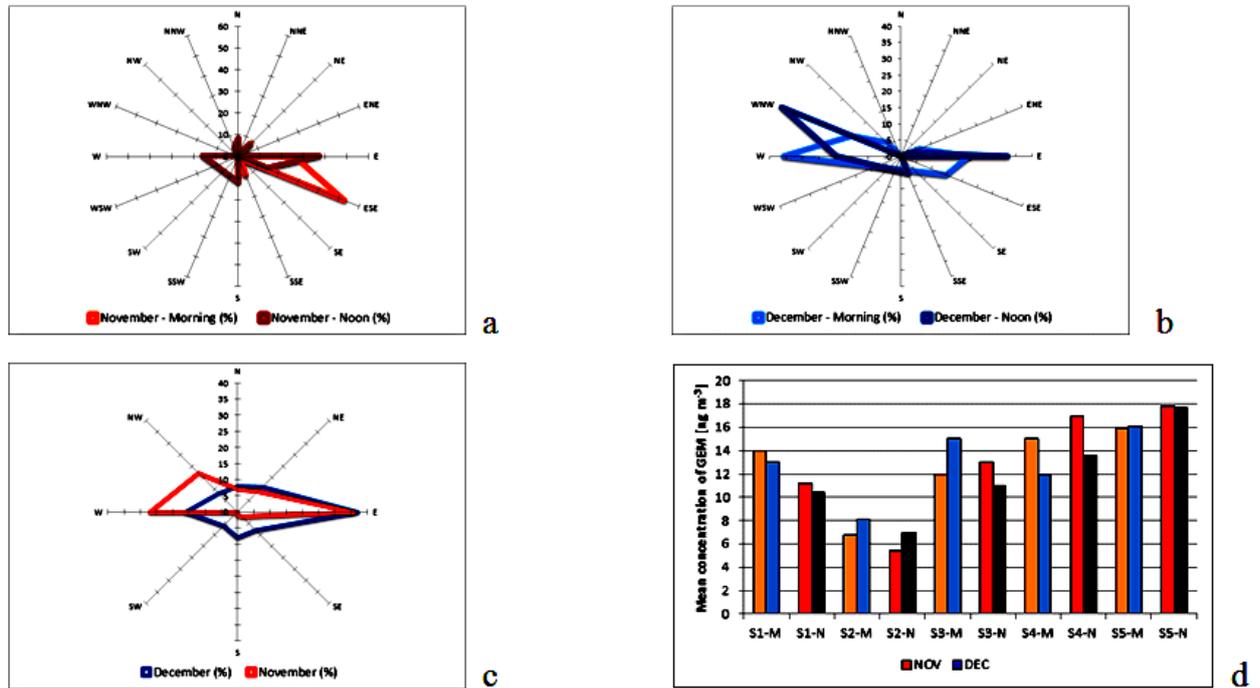
Fig. 4. Variation of mercury concentration and frequency distribution of the wind during November-December 2012 campaign, a) November- morning and noon; b) December- morning and noon c) monthly wind frequency; d) monthly GEM concentration (ng/m³)
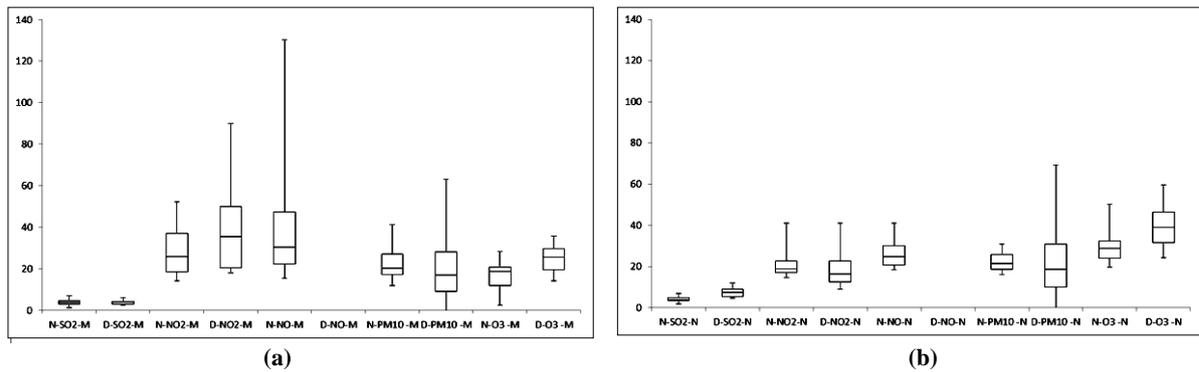
Fig. 5. Concentration of priority pollutants including SO_2, NO_2, NO, PM10, O_3 (µg/ m³) in Iasi, IS3- Oancea-Tatarasi, - Air quality monitoring network in Iasi - industrial station type a) – morning; b) noon. The whiskers represent confidence interval between 25% and 75%

Table 2. Descriptive statistics of heavy metals concentration in urban dust of Iasi industrial area and reference value (mg/kg)

	Cd	*Co*	*Hg*	*Cr*	*Ni*	*Pb*	*Cu*	*Zn*	*Mn*	*Fe*
Min	0.08	3.05	0.18	12.24	14.20	23.76	31.54	14.62	385.00	12352.77
Max	6.83	11.30	0.70	63.80	66.37	165.27	127.59	1922.22	944.12	36533.02
Mean	0.82	7.03	0.48	28.76	30.67	52.96	51.41	366.51	541.12	19056.84
st dev.	1.14	2.28	0.13	13.15	11.12	30.72	20.87	459.15	93.70	5629.24
Kurtosis	23.14	-0.59	-0.19	1.27	1.74	4.59	3.54	4.05	8.99	1.90
Skewness	4.45	-0.19	-0.36	1.26	0.72	2.04	1.60	2.14	2.30	1.42
MAL Kloke*	*3.00*	*50.00*	*2*	*100.00*	*50.00*	*100.00*	*100.00*	*100.00*	*-*	*-*
756/1997 NV**	*1.00*	*15.00*	*0.10*	*30.00*	*20.00*	*20.00*	*20.00*	*100.00*	*900.00*	*-*
756/1997 AT s **	*3.00*	*30.00*	*1.00*	*100.00*	*75.00*	*50.00*	*100.00*	*300.00*	*1500.00*	*-*
756/1997 IT s **	*3.00*	*50.00*	*2.00*	*300.00*	*150.00*	*100.00*	*200.00*	*600.00*	*2500.00*	*-*

Notes: *Maximum allowable limits (MAL) after Kloke (1980);
**Order 756 of MAPPM (1997) (R.O.M., 1997): NV – normal values; ATs – alert threshold for sensitive uses; IT s- intervention threshold for sensitive uses.
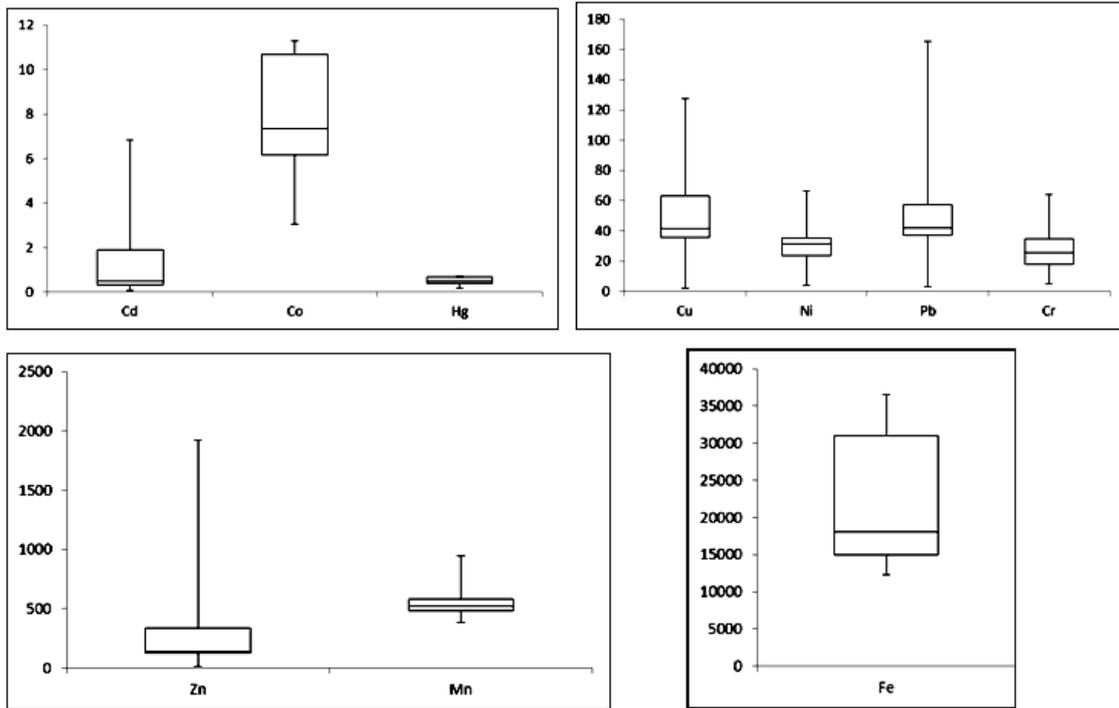
Fig. 6. Box and whisker plot of heavy metals from urban dust during December 2012 campaign compared with mercury in the urban dust of Iasi industrial area. The whiskers represent a confidence interval between 10% and 95%.
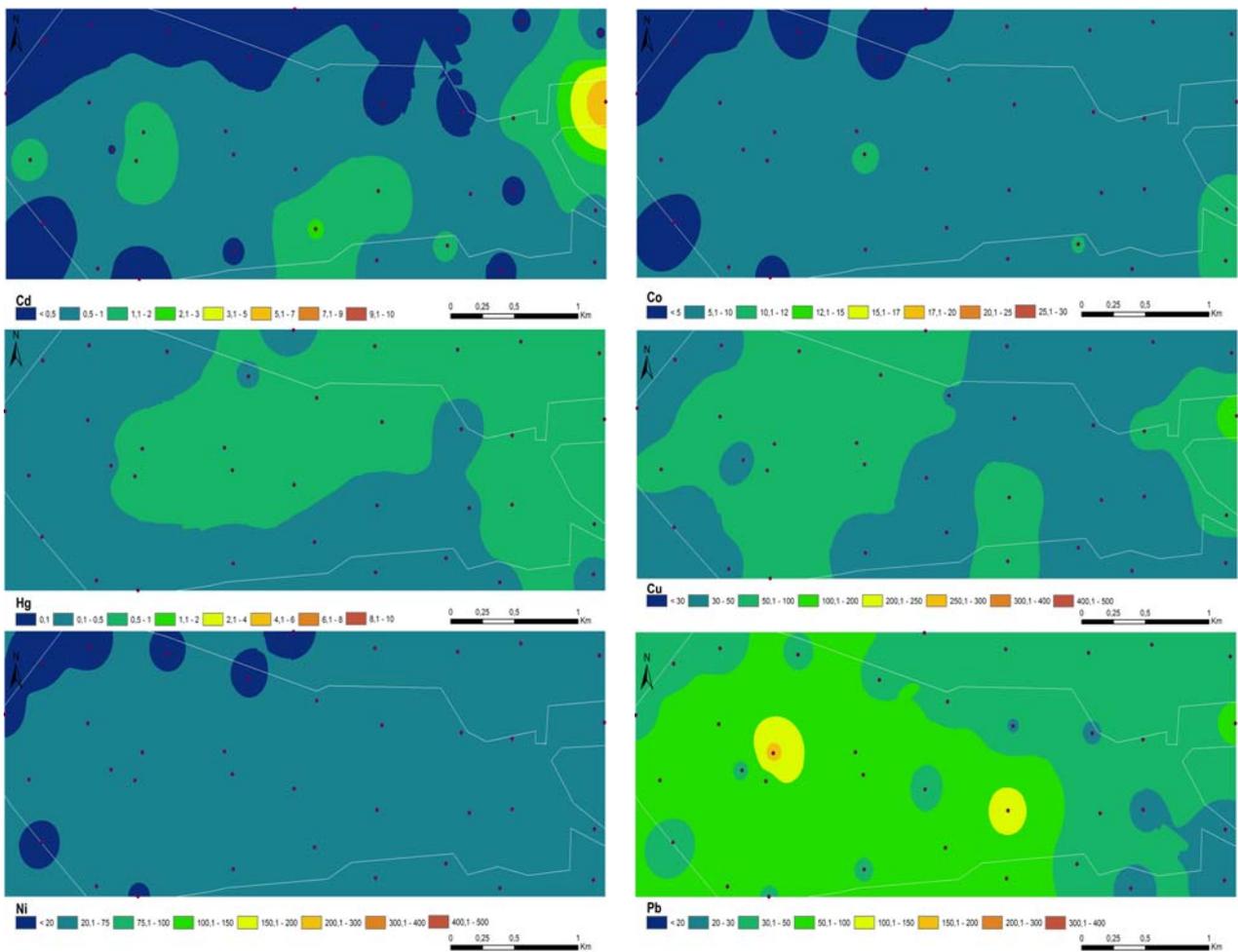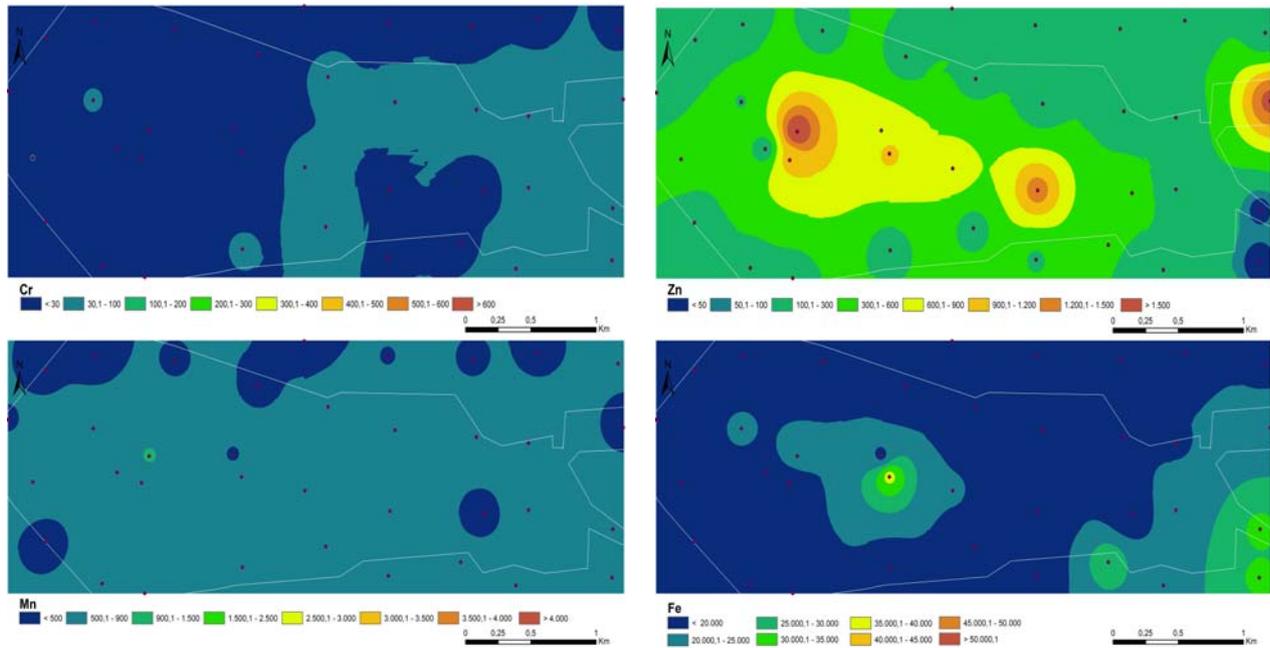
Fig. 7. The geochemical map of heavy metals concentration in urban dust of Iasi industrial area (mg/kg)

Table 3. Correlation between heavy metal concentrations from urban dust

	Hg	*Cd*	*Co*	*Cu*	*Pb*	*Ni*	*Cr*	*Zn*	*Mn*	*Fe*
Hg	1									
Cd	0.34	1								
Co	0.48	0.34	1							
Cu	0.24	**0.64**	0.01	1						
Pb	0.11	0.24	0.19	0.47	1					
Ni	0.45	0.32	**0.85**	0.07	0.33	1				
Cr	0.37	0.38	0.59	0.01	-0.19	0.49	1			
Zn	0.36	**0.62**	0.31	**0.61**	**0.77**	0.42	0.01	1		
Mn	0.29	0.06	0.57	0.13	0.6	**0.75**	0.33	0.48	1	
Fe	0.42	0.19	**0.85**	0.08	0.06	**0.73**	0.42	0.19	0.48	1

Value >0.6 are shown in bold

It is found that different sources or process might control the emissions. For Co, the highest correlation is found with Ni and Fe (0.85), which indicated the importance of industrial sources (stainless steel studs, paint from renovated facade) with high transportation traffic density (road dust vehicle exhaust). Also a high correlation coefficient between Pb with Zn (0.77) was observed, expressing both wear of tires and industrial emissions, as well as between Ni with Mn and Fe (0.75).

A medium correlation coefficient was noticed between Cd with Cu (0.64) and Zn (0.62) as well as Cu with Zn (0.61) caused by brake wear of different steel alloys. The problem is more complex, the actual urban landowners crossing through a functional area urban reconversion, that require different decontamination techniques for soil cleanup (Caraiman et al., 2012; Cretescu et al., 2013; Pavel and Gavrilescu, 2008).

5. Conclusions

This study aimed to identify the mercury generation source in the industrial area of Iasi city, pointing out its environmental behavior and its distribution between the dust and atmospheric air, in dependence of meteorological conditions. The study shows a raised level of mercury in the urban atmosphere of Iasi city, compared with those of the background, highly variable, due to both anthropogenic/urban emissions and meteorological effects.

The results prove the anthropogenic contribution from industrial area of Iasi city to the mercury level in the urban air and roadway dust. There are some clear differences, in terms of mercury generation, between different types of traffic: continuous, start –stop, parking lots. The presence of waste water treatment plant has also contributed to the mercury generation in the monitoring area, having a negative environmental impact.

 – on the roads was 0.50 mg/kg dry weight (range 0.18-0.68 mg/kg),

 – in the parking lots was 0.47 mg/kg dry weight (range 0.31-0.63 mg/kg),

 – in the power plant and waste water treatment plant area was 0.59 mg/kg dry weight (range 0.48-0.7 mg/kg).

The highest values can be found in the dust, collected from the area located near the power plant, which is the main mercury generation source.

Further studies are required to investigate the characteristics of the waste and the area pollution history related mainly to the public health of people which work or transit the area. The geochemical maps are very useful both for scientists and professionals working towards the restoration of contaminated areas.

Knowing the contamination level, an important first step towards remediation of the problem was made. The past history of the sites has a continuing impact. Based on the results of this study, it is clearly that the soil, as well as dust from the monitoring area was excessively contaminated, suggesting a remediation procedure in order that this area to be considerate appropriate for different purposes as: commercial, residential or parking etc.

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