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IDENTIFYING POLLUTANTS IN THE SIRET RIVER BASIN BY APPLYING NEW ASSESSMENT TOOLS ON MONITORING DATA: THE CORRELATION OF LAND USE AND PHYSICO-CHEMICAL PARAMETER OF WATER QUALITY ANALYSIS

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Key words: Sources of pollution, water quality monitoring, GIS, land, use, catchment.

Abstract. The Siret River are used as raw water source for different municipal water supply systems, yet the Siret River are used as receiving bodies by some inhabitants and industry. In the study the quality of the Siret River water was determinate using a Water Quality Index (WQI). Results are presented from a field study performed on the Bistrita, Moldova, Suceava, Siret, Şomuzu Mare, Trotuş and Tributary River in the study area Siret Basin Romania. The main objective of this study was to determine is to find correlations land use to indicators physical-chemical of water quality, to investigate pollution source is more responsible for river water quality. This is of interest not only research context, but also for supporting and facilitating the application analysis postullend in the Water Framework Directive (WFD) (2000/60/CE) for the establishment of programmers of measures. For this purpose a slightly impact pollution source municipal wastewater treatment, land uses, urban, forest, agriculture and mining was selected and intensively monitored during six years January 2006 – December 2011, sampling was determined to meet the WFD standards for confidence in twenty two different control section of the Siret Basin. The main measures to reduce emissions to the Siret River were calcium, ammonium, sulfate, residue fixed (RF), sodium, chloride, free detergent and municipal wastewater treatment, concentrated on point emission. The main contributor to diffuse this parameters increased when more percentage of land was dedicated to industry and urban and less to forest and mining.

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Introduction

This study identifies data and information requirements, pinpoints difficulties the impact of pollution source, analysis of water quality and monitoring control. The main measures to reduce emissions to the Siret River were calcium, ammonium, hydrogen sulfide, residue fixed (RF), sodium, choride, free detergent and municipal wastewater treatment, concentrated on point emissions. (Behrendt and Bachor, 1998; Laane et. al., 2002). The aim of this analysis is to find a correlation between land uses, industry, urban, forest, mining and agriculture, for the defined diffuse source of the variation indicators physical-chemical and to deliver strategic guidelines for water protection. The EU Water Framework Directive (WFD) prescribes to achieve a good status of surface waters by 2015 (European Parliament, 2000). To keep this deadline of a new three level surveillance, operational and investigative, monitoring systems is required including hydro-morphological, biological and chemical elements. (Balazs L., et. al., 2006). In consequence, the physical-chemical status of European river should be evaluated and investigated before the year 2015 for a good improved.

This is a strategy for assessing the physical-chemical status of Siret River by using multiple indicators by observed deviation from the expected natural condition. The methodological focus used in this study offers a more global, complete view, as seen in other paper where the use of multiple parameters of analysis of water quality (Roth et. al., 1996, Lammaert and Allan, 1999, Griffth et. al., 2005, Freund and Petty, 2007). In the process of pollution, rivers in a watershed play a major role in assimilating or carrying off municipal and industrial wastewater and runoff from agricultural land (Alexander et al., 2000; Singh et al., 2005). Thus, it is imperative to prevent and control river pollution. Spatial and temporal variations in water chemistry and the locations of the most significant contributors to pollution in a river basin must be clearly identified; this usually requires a monitoring program that will provide a representative and reliable estimation of the quality of surface waters (Alexander et al., 2000; Simeonov et al., 2003). Identification of the point source and non-point source pollution in a watershed with complex river network is an environmental conundrum. Different multivariate approaches offer powerful means of understanding a large environmental datasets and the physical-chemical status of study systems (Simeonov et al., 2003; Singh et al., 2005; Zhou et al., 2007).

The control of diffuse pollution is very important in this paper there for we analyze the effect of some land uses agriculture, urban, forest, mining, industry, responsible for different impact source of water quality. Where agriculture cause point pollution, the level of irrigation impact it is not responsible for high values of the parameter analyzed. Urban often causes is the most important source of diffuse pollution point in the Siret basin. The wastewater discharged is the source

responsible of water quality. Some autors have suggested that the influence of the land uses on water quality must be analysed at the catchment scale (Omernik et. al., 1981; Richards and Host, 1994; Roth et. al., 1996), where others have argued that land uses located closer to stream are more important. (Harding et. al., 1998; Nerbonne and Vondracek, 2001). Many studies suggest a multiple spatial scale approach could be a framework and important source of diffuse pollution. (e.g. Chamg, 2008; Tran et. al., 2010). The effect of urban in TSS, NH_4, RF, Cl, SO_4, Na, Ca river concentration was also in the Siret basin.

1. Material and methods

1.1. Study area. The indices of water quality have to be developed considering the local properties and pollution status of the ecosystems. There are different tools that affect watershed management and to control.

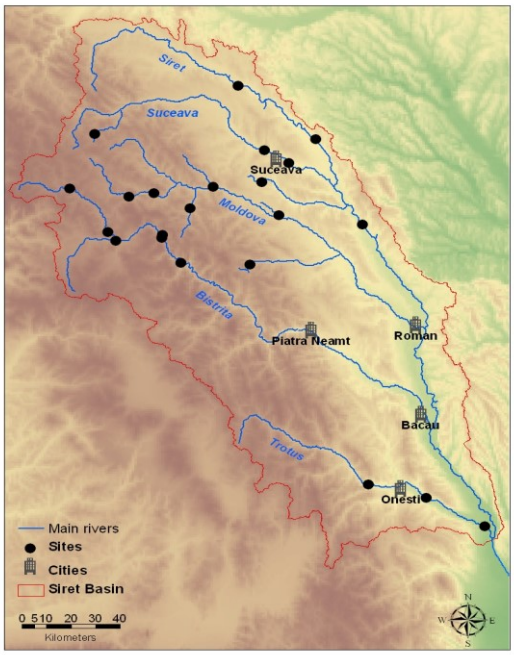

Fig.1. Study area Siret River Basin and the boundaries of river

Water Quality Index is a very important tool in the management of watersheds in this sense. Therefore this study has the potential to provide interesting results for researchers in water quality sector. The study area is Siret River Basin, Administration (ABAS), Romania area that includes the upper and middle reaches

of six large river Bistrita, Moldova, Suceava, Siret, Şomuzu Mare, Trotus and Tributary River (Fig.1). The Siret River Basin, which is the largest basin in Romania, with a 47,610 square kilometers area of which 42890 km on Romanian territory. In this basin area, Siret River Basin Administration Bacău manages 27,402 km. The density of the river network is 0.35 km/sq. km. Siret River, rises in the Carpathian Woody Mountains, in Ukraine enters in Romania near the city of Siret and flows into the Danube, upstream the Galati city. The total length of the Siret River is 726 km, of which the territory of Romania, 559 km. The main tributaries of the Siret River are Suceava River, Moldova River, Bistrita River, Trotuş River, Bârlad River, Putna River, Ramnicu Sarat River and Buzau River, which together with other smaller tributaries, contribute to a multi-annual average flow of Siret River upstream the confluence with the Danube, approximately 240 m^3/s corresponding to a multi-annual average stock of about 7.6 billion cubic meters. The total length of the river system of the Siret River Basin, is 15836 km, of which on the territory of Romania, 15157 km, and managed by Siret River Basin Administration of 10280 km.

Main water courses from the Siret river basin are effluents of Siret river that collects all the waters on the eastern side of the Carpathians rivers namely Suceava, Moldova, Bistriţa, Trotuş, Putna and Ramnicu Sărat, Buzău River. In the surface water resources of the Siret River Basin there are two lakes, one freshwater and one saltwater, their water not being used to meet requirements of water using.

Areas occupied by forests and bushes are there (58.29%), are being developed and expanded on surfaces in compact, high relief areas (Fig.2). Perennial crops and heterogeneous agricultural areas (12.17%) have a relatively uniform development throughout the surface of the water. Arable land represents lie on the east side of the basin of hilly area and along the embankment of the Siret River in percentage (22.7%). Other occupies the area significantly lower. Thus, the water occupies a large proportion of 0.59% and wetlands occupy a large proportion of 0.08% (Fig.2). The Siret River basin in the area is the predominant type of calcareous rocks, limestone with a North-South alignment, with relatively small areas along the Carpathian Arc, crystalline-mesozoic area. In the northern part of the West are small areas of organic material. Underground water resources and deep groundwater are located in most major rivers Siret, Suceava, Moldova and Bistriţa, groundwater is estimated at 28 mc/s whereby 16,7 mc/s are balance resources. Unlike other rivers, Siret River has several major tributaries, which are expressed more strongly by the variation of annual average flow along its course (Suceava 9%, Molodva 17.6%, Bistriţa 35%, Trotuş18%). Water pollution is reduced substantially from its initial value due to its self-purification capacity. Treated or untreated wastewater, after evacuation processes are subjected to physical, chemical and biological processes that lead - finally - to water self-purification of

the receptor.

1.2. Land use data

The development of geographical information system (GIS) tools has allowed more sophisticated questions to be asked about how community composition in a stream is related to its physical setting at a variety of scales (McDonnell,2000). In this context, attention has often been focused on whether conditions in the catchment have been strongly modified by human influence, agriculture, forestry, mining, industry, or are largely natural (Basnyat et.al., 2000; Manel et.al., 2000; Prosser et.al. 2001). Some researchers have used exploratory data analyses to elucidate relationships in their data (e.g. Carter et. al., 1996; Allen et.al., 1999; Li et.al., 2001; Monaghan et.al., 2000) while others have built predictive models (e.g. Manek et.al., 2000), which may be of direct use for management purposes. All geographic data management was carried out whit Arc GIS 9.2. Land use percentage composition for each site was quantified with four different spatial scales. Total upstream drainage are for each location was delineated based on data and images form the USGS HydroSHEDS and BioFresh dataportalBiodiversityofFreshwaterEcosystems,http://data.freshwaterbiodiversity.eu/shapefiles.htmland http://hydrosheds.cr.usgs.gov.

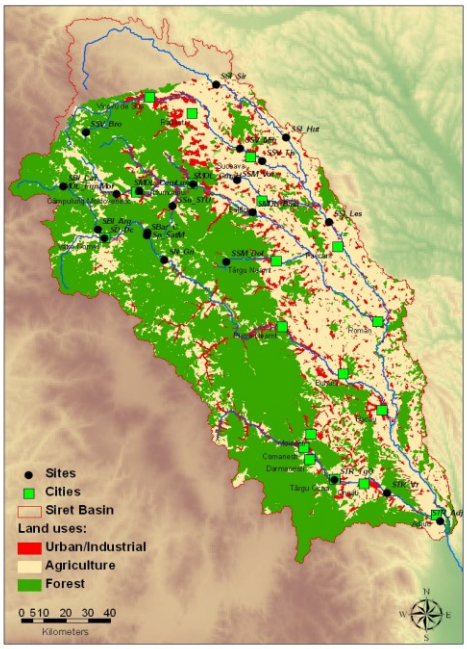

Fig.2. Study area Siret River Basin the boundaries of river and land use

In this paper, we analyze data base of 22 sites in the Siret River Basine using a newly developed GIS.

The objectives were to determine which scale of landscape variables accounts for most variation of parameter physical chemical, geographical position, catchment, whether natural or human induced physical setting, impact pollution.

Tab. – 1 Description of land uses analyzed Corine Land Cover categories

Code	**Description**	**Corine Land Cover categories**
Urban	Urban Industrial Wastewater discharged	1. Artificial areas
Mining	Extractive mining industry Construction sites Mining water Dump sites	2. Artificial areas
Agriculture	Cereals, legumes, fruits trees	3. Non-irrigated arable land Agricultural areas
Forest	Areas with natural vegetation	4. Forest and semi-natural vegetations areas
Water	Water courses Salinas	5. Water bodies

Was obtained by Geographical Information System (GIS) software (ESRI ArcMap 8.2). The GIS has been using the more recent database from regional and national sources. The category land uses data is: urban, forest, mining and agriculture. Land use data were obtained from the Corine Land Cover (CLC, 2000). Land cover classes characterized in CLC were reclassified intro the following category (Table 1). Areas to agricultural (AGR), urban and industrial land covers (URB), natural and forested vegetation (FOR), mining and extractive mining (MIN) and water (WAT). Urban land use was also split intro three categories: industrial, wastewater discharged and urban, expected to have o low impact on quality water of Siret River.

1.3. Physical – chemical analyses

Water pollution is reduced substantially from its initial value due to it's self-purification capacity. Treated or untreated wastewater, after evacuation processes are subjected to physical, chemical and biological processes that lead - finally - to

water self-purification of the receptor. The main source of pollution of the Siret River is due mainly to disposal of wastewater and usually directed by inappropriate treatment. Pollution of the Siret River, the urban sewage treatment station downstream of city, due to sewage discharged and improperly purified by the purge station. In this situation the water quality is influenced by the presence of Ca, N-NH_4, RF, Na. This fact demonstrates the strong influence of urban in stream water Ca, N-NH_4, RF, Na level within the study area.

The main sources of pollution in the catchment area have influenced the state of its river water quality. The highest pollution input was recorded in the Siret Basin coming the tow tributaries (Suceava, Bistrita, Moldova, Şomuzu Mare, Trotuş) due at least partly to the collection of urban wastes from the metropolitan of Suceava, Bacau. Mean values of Ca, N-NH_4, RF, Na due to extensive urban use and accidental pollution (Table 4).

1.4. Statistical analyses

Statistical analyses were performed using STATISTICA StatSoft v.10 and XLSTAT. Statistical software was used for all statistical treatments such as basic statistic, analysis of variance and correlations. In this case we calculate Sperman's rank correlation coefficient for each scale dataset. Basic statistical analysis has been conducted in order to gain some insight into the structure of the dataset.

Tab. – 2 Description total drainage area of upstream sub catchment (DA)

Section Siret River basin	Urban %	Mines %	Agriculture %	Forest %	Water %
SBar_C	0.12	0.00	16.78	83.10	0.00
SBI_Arg	6.97	0.00	80.74	12.29	0.00
SBI_Car	27.14	0.00	56.36	16.50	0.00
SD_Dc	78.42	0.00	3.72	17.86	0.00
SMOL_Baia	40.18	0.00	59.82	0.00	0.00
SMOL_CamLung	75.34	0.00	5.1	19.56	0.00
SMOL_Fun Mol	32.64	0.00	37.88	29.48	0.00
SMOL_GuraHum	57.87	0.00	0.00	35.79	6.34
SN_Gn	30.75	0.00	35.84	24.14	9.27
SP_Sat M	13.63	0.00	52.04	28.19	6.14
SSI_Hut	0.00	0.00	100.00	0.00	0.00
SSI_Les	41.11	0.00	40.42	0.00	18.47
SSI_Sir	26.64	0.00	63.74	0.00	9.62
SSM_Dol	23.55	0.00	0.00	76.45	0.00
SSM_Vor	4.17	0.00	95.83	0.00	0.00
SSU_Stu	44.04	0.00	38.74	7.23	9.99
SSV_Bro	0.00	0.00	49.99	50.01	0.00
SSV_Mih	5.80	0.00	79.84	0.00	14.36
SSV_Tis	50.52	0.00	22.66	0.00	26.82
STR_Adj	0.00	0.00	55.62	0.00	44.38
STR_TgO	71.48	0.00	21.70	0.03	6.79
STR_Vr	9.49	0.00	75.82	4.98	9.71

For the estimation of statistical properties of the data, the missing values have been temporarily ignored and the dataset has been scaled.

According to the characteristics of their special distribution, the pollution sources are classified as point sources, non-point sources and internal sources discharged into rivers and lakes. Point pollution sources mainly include industrial and domestic wastewater from urban areas. Non-point pollution sources comprise of the pollutants from surface runoff from agriculture lands, town lands, woodlands, meadows and so on (Wang C. et.al., 2005).

The pollution loads of urban point source are non-point sources. It indicates that the amount of Ca, N-NH_4, RF, SO_4, Na, BOD5 from urban point sources is about 68% of the total (Fig.3).

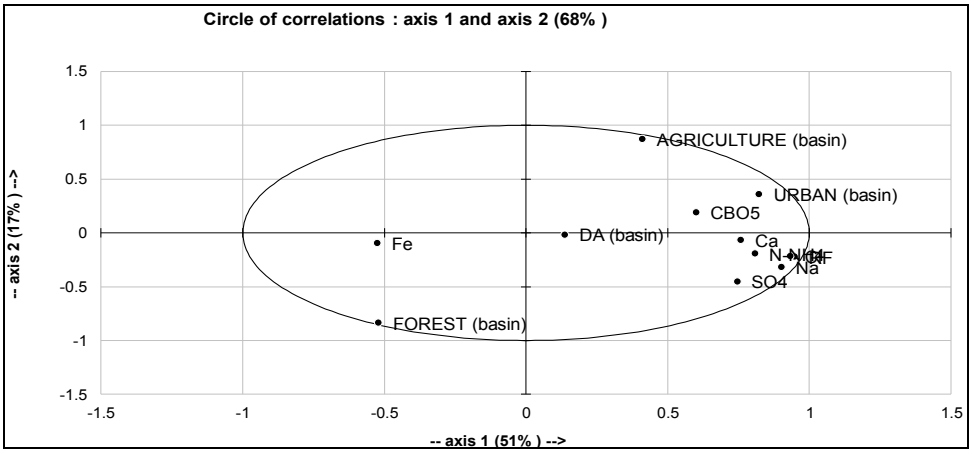

Fig.4. Correlation of non-point pollution sources of river and land use

So point sources are overwhelmingly and should be the priority for control and abatement. Non-point pollution sources should also be paid adequate attention.

The urban point pollution sources are the principal sources, the non-point pollution sources take the second place, and the internal pollution sources are less significant.

So wastewater treatment plants in cities and towns along the main route should be built as soon as possible to ensure the water quality in Water Framework Directive (WFD) (2000/60/CE).

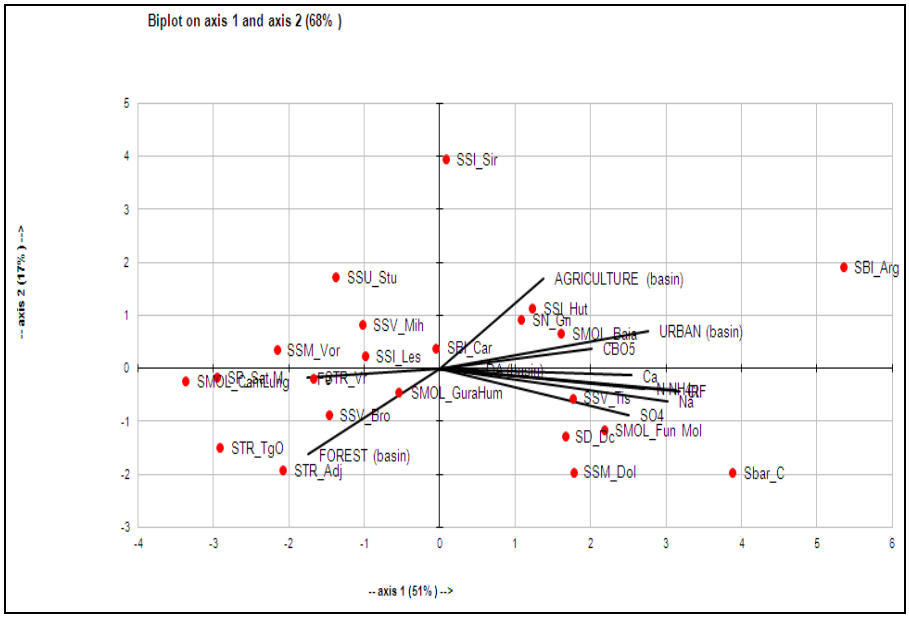

Fig.4. Correlation of non-point pollution sources of Siret River section and land use

2. Results

This study is concerned with ambient water quality in Siret River Basin. For the analysis data on water quality for 22 monitoring points on 6 important rivers for six years 2006-2011 are used. These data collected under the water quality monitoring program of the government have been taken from the web site of the Siret Regional Water (www.apesiret.uvp.ro.). Most of the selected sites matched with the Water Framework Directive criterion of being free from human influence. Inasmuch as the discharge of urban wastewater is an important cause of pollution of Siret Rivers, one should expect a negative relationship between urbanization and river water quality. The preliminary results of the model, however, did not show such a relationship (Fig.3) and (Table 4). A closer examination of the data suggested a relationship between urbanization and water quality. The water quality deteriorates as urbanization goes up, but beyond a stage further increases in the level of urbanization tend to be beneficial (Bishwanath G. and Nandini B., 2004). The best results that could be obtained in respect of the urbanization variable are shown as model estimate in Table 3.

The coefficient of urbanization has a negative coefficient while the agriculture, forestal of this variable has a positive coefficient. Both coefficients are statistically significant. An increase in urbanization causes deterioration in river

water quality. However, the results do hint at an adverse effect of urbanization on river water quality up to a stage.

Tab. – 3 Correlation and PCA analysis with coefficient type Sperman's

SIRET RIVER (basin)	URBAN (basin)	AGRICULTURE (basin)	FOREST (basin)	DA (basin)	N-NH4	RF	BOD5	Cl	SO4	Ca	Na	Fe
URBAN (basin)	1	0.5720	-0.7064	0.2772	0.5042	0.6601	0.5483	0.7391	0.4433	0.5404	0.6228	-0.4458
AGRICULTURE (basin)	0.5720	1	-0.9774	-0.0435	0.2084	0.2174	0.3123	0.1925	-0.0220	0.2445	0.1078	-0.2532
FOREST (basin)	-0.7064	-0.9774	1	-0.0073	-0.2874	-0.3145	-0.3992	-0.3123	-0.0627	-0.3055	-0.2151	0.3001
DA (basin)	0.2772	-0.0435	-0.0073	1	-0.1225	0.0198	-0.0864	0.1372	0.1350	0.1316	0.0898	-0.4142
N-NH4	0.5042	0.2084	-0.2874	-0.1225	1	0.8622	0.5020	0.7267	0.6307	0.5720	0.7945	-0.2024
RF	0.6601	0.2174	-0.3145	0.0198	0.8622	1	0.5031	0.9334	0.7628	0.7357	0.9413	-0.4554
BOD5	0.5483	0.3123	-0.3992	-0.0864	0.5020	0.5031	1	0.5234	0.2332	0.3529	0.4975	-0.1160
Cl	0.7391	0.1925	-0.3123	0.1372	0.7267	0.9334	0.5234	1	0.8114	0.6556	0.9300	-0.3961
SO4	0.4433	-0.0220	-0.0627	0.1350	0.6307	0.7628	0.2332	0.8114	1	0.5155	0.7956	-0.3701
Ca	0.5404	0.2445	-0.3055	0.1316	0.5720	0.7357	0.3529	0.6556	0.5155	1	0.6160	-0.4876
Na	0.6228	0.1078	-0.2151	0.0898	0.7945	0.9413	0.4975	0.9300	0.7956	0.6160	1	-0.3656
Fe	-0.4458	-0.2532	0.3001	-0.4142	-0.2024	-0.4554	-0.1160	-0.3961	-0.3701	-0.4876	-0.3656	1

The highest pollution input was recorded in the Siret River coming from the four tributaries (Trotuş, Bistrita, Moldova, Somuzu Mare) due at least partly to the collection of urban, industrial wastes and salinity. Mean value of Ca, N-NH_4, RF, SO_4, Na and BOD5, were higher in large rivers because of the high percentage of both urban use. Because the water of the rivers is vulnerable to pollution sources (the collection of domestic and industrial wastewater of city) in the drainage basin of the River Trotuş were delineated four "zones of protection" related over the surface. In the drainage basin of the River Trotuş importance are mineral waters. Critical areas that require improvement in the quality of the water in terms of ecological status. Disturbing sources are presented based on the critical areas of the basin in which it appeared that the impact of the degradation of water quality. Due to the fact that industrial objectives were developed in urban centers, municipal sewage may comprise of a mixture of household waste, waste water, industrial and waste water from various activities, including public water from precipitation and, in the area of the river basin was used notably Trotuş channeling in the system unit.

Thus, on the variation of concentrations of chlorides can affirm that they grow significantly from upstream to downstream, source of chlorides being Tg.Ocna area, where natural resources are occupied by salt, taking place in Vrânceni comparative strengths with the Tg.Ocna, but which fall within the category III water quality of (WFD) the Trotuş River.

The main source of pollution of the Şomuzu Mare River is due mainly to disposal of wastewater and usually directed by inappropriate treatment. Based on the monitoring indicators agreed levels, grade falls into water courses. For knowing the quality of water flowing in the Siret River basin during the year 2010 have collected from river water samples Şomuzu Mare Vorniceni and Dolheşti city. The main sources of pollution in the catchment area have influenced the state of its river water quality. After analyzing the variation in quality indicators increased physical - chemical river water quality Şomuzu Mare Dolheşti monitoring section in 2010, decreased due to nitrite indicator, inducing a weak class quality Şomuzu Mare River , falling in the fourth grade of quality. The main sources of river pollution in Moldova can be ranked according to: the impact on the pollutant toxicity evacuated in receiver, potential or actual danger they pose to downstream users, the amount limits set for evacuated contaminants.

Tab. – 4 Analysis some parameters of relatively unpolluted with coefficient type Spearman's

SIRET RIVER (basin)	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8	factor 9	factor 10	factor 11	factor 12
URBAN (basin)	0.8224	0.3601	0.1364	0.2167	-0.1174	0.0422	-0.1485	-0.2167	0.2041	0.0430	0.0140	0.0129
AGRICULTURE (basin)	0.4110	0.8695	-0.0670	-0.1684	-0.1289	0.0154	0.0424	0.1071	-0.0980	-0.0121	0.0161	0.0454
FOREST (basin)	-0.5202	-0.8348	0.0471	0.0817	0.1350	-0.0079	-0.0110	-0.0401	0.0151	-0.0086	0.0206	0.0542
DA (basin)	0.1377	-0.0168	0.8623	0.3904	-0.1112	0.1880	0.1665	0.0824	-0.0492	-0.0138	0.0058	-0.0024
N-NH4	0.8085	-0.1946	-0.3354	-0.0744	-0.0296	0.0863	0.4059	0.0046	0.1286	-0.0122	-0.0251	0.0067
RF	0.9495	-0.2226	-0.0936	-0.0981	0.0181	-0.0032	0.0613	-0.1017	-0.0756	-0.0628	0.0784	-0.0173
BOD5	0.6022	0.1891	-0.3643	0.5335	0.3710	-0.1542	-0.0157	0.1503	-0.0038	-0.0004	0.0055	0.0000
Cl	0.9341	-0.2153	-0.0154	0.0898	-0.1254	-0.0207	-0.1566	-0.0739	-0.0768	-0.1347	-0.0504	0.0074
SO4	0.7466	-0.4537	0.0746	-0.1140	-0.2922	-0.1272	-0.1379	0.2947	0.1000	0.0230	0.0128	-0.0019
Ca	0.7587	-0.0690	0.1267	-0.2560	0.3812	0.4087	-0.1396	0.0751	0.0083	0.0213	-0.0084	0.0004
Na	0.9014	-0.3194	-0.0776	0.0566	-0.1000	-0.0473	0.0206	-0.0919	-0.1851	0.1432	-0.0170	0.0032
Fe	-0.5239	-0.0948	-0.6356	0.2744	-0.2952	0.3780	-0.0682	0.0399	-0.0282	-0.0003	0.0124	-0.0029

The main source of pollution of the Bistriţa River are mining and urban, they raised a number of pressing issues affecting the environmental factors. Water pollution is reduced substantially from its initial value due to its self-purification capacity. Treated or untreated wastewater, after evacuation processes are subjected to physical, chemical and biological processes leading to water self-purification of receptor. This is because in some areas affected by pollution from mines, streams have low flow rates.

Water pollution is achieved in several ways: mine drainage water (slightly acidic water), discharge to surface waters, pollution of surface material from waste dumps, water washing by precipitation, infiltration of the operation in underground

aquifers, loss of fuel or lubricants from equipment equipped with internal combustion engines, sawdust resulting from cutting the material used to reinforce galleries. After monitoring the river water quality was determined concentration Bistriţa Ca, N-NH_4, RF, SO_4, Na, BOD5, Cl and Fe in the control section Bărnar, Bărnărel - Crucea, Argeşu and Cârlibaba. In terms of ion content in setting state water quality leads to the Siret River water quality classification as "moderate"class.

Tab. – 5 Analysis some parameters of relatively unpolluted with coefficient type Spearman's

SIRET RIVER (basin)	1	2	3	4	5	6	7	8	9	10	11	12
Value	6.1452	2.0741	1.4547	0.6992	0.5434	0.3974	0.2886	0.2078	0.1272	0.0460	0.0109	0.0056
% of variability.	0.5121	0.1728	0.1212	0.0583	0.0453	0.0331	0.0240	0.0173	0.0106	0.0038	0.0009	0.0005
Cumulated %	0.5121	0.6849	0.8062	0.8644	0.9097	0.9428	0.9669	0.9842	0.9948	0.9986	0.9995	1.0000
Vectors :	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
URBAN (basin)	0.3318	0.2500	0.1131	0.2591	-0.1593	0.0669	-0.2765	-0.4753	0.5722	0.2007	0.1338	0.1721
AGRICULTURE (basin)	0.1658	0.6038	-0.0556	-0.2014	-0.1748	0.0244	0.0790	0.2350	-0.2748	-0.0566	0.1536	0.6078
FOREST (basin)	-0.2098	-0.5796	0.0391	0.0977	0.1831	-0.0126	-0.0205	-0.0880	0.0423	-0.0401	0.1972	0.7244
DA (basin)	0.0555	-0.0117	0.7149	0.4669	-0.1509	0.2982	0.3100	0.1807	-0.1378	-0.0645	0.0559	-0.0315
N-NH4	0.3261	-0.1351	-0.2781	-0.0890	-0.0402	0.1369	0.7556	0.0101	0.3607	-0.0570	-0.2396	0.0895
RF	0.3830	-0.1546	-0.0776	-0.1174	0.0246	-0.0050	0.1142	-0.2230	-0.2120	-0.2927	0.7499	-0.2308
BDO5	0.2429	0.1313	-0.3020	0.6380	0.5033	-0.2446	-0.0293	0.3297	-0.0105	-0.0018	0.0523	-0.0002
Cl	0.3768	-0.1495	-0.0128	0.1074	-0.1701	-0.0329	-0.2915	-0.1621	-0.2152	-0.6280	-0.4818	0.0991
SO4	0.3012	-0.3151	0.0618	-0.1363	-0.3964	-0.2017	-0.2567	0.6466	0.2803	0.1072	0.1226	-0.0256
Ca	0.3060	-0.0479	0.1051	-0.3061	0.5172	0.6483	-0.2599	0.1647	0.0232	0.0992	-0.0804	0.0052
Na	0.3636	-0.2218	-0.0643	0.0677	-0.1357	-0.0750	0.0384	-0.2017	-0.5191	0.6679	-0.1622	0.0432
Fe	-0.2113	-0.0658	-0.5270	0.3282	-0.4004	0.5996	-0.1270	0.0875	-0.0791	-0.0012	0.1189	-0.0389

3. Discussion

According to the WFD the assessment of the physical-chemical status of water bodies should be performed using physical-chemical indicators. This has generated a debate among the scientific community regarding the use indicators group and land use to evaluate quality water. Industrial production without adequate regard for environmental impacts has increased water and air pollution, and has led to soil degradation and large-scale global impacts such as acid rain, global warming, and ozone depletion (Seth S.M., 2003). Many studies have discussed which physical-chemical elements are apporiate for defining (Wang C.et. al, 2005; Shuguang L.et al, 2011; Y.C. Lai et.al., 2011; Jinzhu M. et.al., 2009; Akkoyunlu A and Muhammed E.A., 2012).

In the present study we used physical-chemical elements to study the impact of quality water Siret River Basin.

According to the European Environmental Agency, in many catchments the main source of N-NH_4, Ca, RF, SO_4, Na, BOD5, Cl and Fe pollution is form urban land and discharges from wastewater treatment (EEA, 2003). The relationship between land uses and N-NH_4(> 0,3 mg/l), RF(>500 mg/l), SO_4(>150 mg/l), Na(>50 mg/l), BOD5(>5 mg/lO_2), Cl (>100 mg/l) and Fe (>0,3 mg/l) and Ca (>300 mg/l) concentration in this study produced important conclusions. Urban use increased showed negative correlation correlations whit N-NH_4, RF, SO_4, Na and Cl. Ammonium, BOD5 and ammonia was correlated whit urban use, thus indicating high industrial and population densities.

The urban sewage also produces serious pollution in some rivers studied, for example in the Siret River Basin, which receives high urban and industrial inputs of pollution from the Trotuş River. The pollution effect in the Siret River Basin has been amplified due to upstream water and other interbasin (for example Suceava River, Bistrita River, Somuzu Mare River, Moldova River). Between 1993 - 2003 there were 184 pollution incidents, with a minimum of 10 pollution in 1996 and a maximum of 28 in 2001. of the total pollution accidents occurring in this period 46.2% were recorded Trotuş River and its tributaries, 26.1% were recorded on Bistriţa River and its tributaries, and 9.8% were registered on the Siret River. The central objective of the Water Framework Directive (Directive 2000/60/EC) is to achieve "good status" for all water bodies, both the surface and those of groundwater, except bodies and heavily modified artificial, which defines "good ecological potential."

Conclusions

The paper investigated determinants of water quality in rivers in Romania, particularly the effectiveness of informal regulation in controlling pollution of rivers. Data on water quality (water class) for 22 monitoring points for six years (2006 – 2011) were used for the analysis. Given the nature of the water quality data, an ordinary regression analysis could not be applied. The statistical analysis was therefore carried out by using a StatSoft v.10 program. The results indicated a positive relationship between land use and water quality in rivers. A significant negative relationship was found between the levels of industrialization and urban the water quality in the monitoring point falling in the district. A significant positive relationship was found between agricultural, forest percentage and water quality. The results also indicated a positive relationship between the water quality in rivers flowing through and mining. These results may be taken as indicative of a significant favorable effect of WFD water quality rivers in Siret River Basin.

Acknowledgments. This paper was realized with the support of POSDRU CUANTUMDOC "DOCTORAL STUDIES FOR EUROPEAN PERFORMANCES IN RESEARCH AND INOVATION" ID79407 project funded by the European Social Found and Romanian Government.

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THE IMPACT OF HEAVY RAINFALL IN THE HYDROLOGICAL REGIME OF SUHA RIVER BASIN IN 2006

Alina Tirnovan [1,2], Gheorghe Romanescu[1] , Gianina Maria Cojoc[1,2]

Key words: heavy rainfall, hydrological regime, flooding, damage

Abstract. Recent climate changes mentioned in the Intergovernmental Panel for Climate Change (IPCC, 2013) report highlight the fact that in the past 50 years at the planetary level have occurred major changes in all climate components. In this regard the analysis of rainfall oscillations and of their impact on the hydric regime is particularly important, being witnessed in the surface and groundwater level variations. In the Suha River Basin, the year 2006 has been characterized by large rainfall quantities that have been generated, in particular, in June by persistent retrograde cyclonic activity (223 mm at Slătioara 3 hydrometric station, 269.1 mm at Gemenea 5 station, 271.6 mm at Valea lui Ion station and 351.8 mm at Stulpicani). On the main course of Suha, but especially on its tributaries (Gemenea and Slătioara) have been recorded very high flow rates (5% and 2% insurance) caused by the amounts of rainfall felt in a short time. To estimate the impact of rainfall on the Suha basin hydrological regime we used data collected by the Siret Basin Water Administration-Bacau, being analyzed the rainfall quantities, duration, intensity, tendency and effects.

Introduction

Suha River Basin mostly overlaps the sandstone formations of Stânişoarei Mountains, and only its western part is formed on the crystalline Mesozoic formations belonging to the Rarău Mountains. The main collector is Suha, right tributary of the Moldova River. It gathers important tributaries both on the left and on the right side, reaching a basin surface of 356 km^2. It is located

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at the intersection of the 25°45'20" east longitude meridian with the 47°26'57' north latitude parallel.

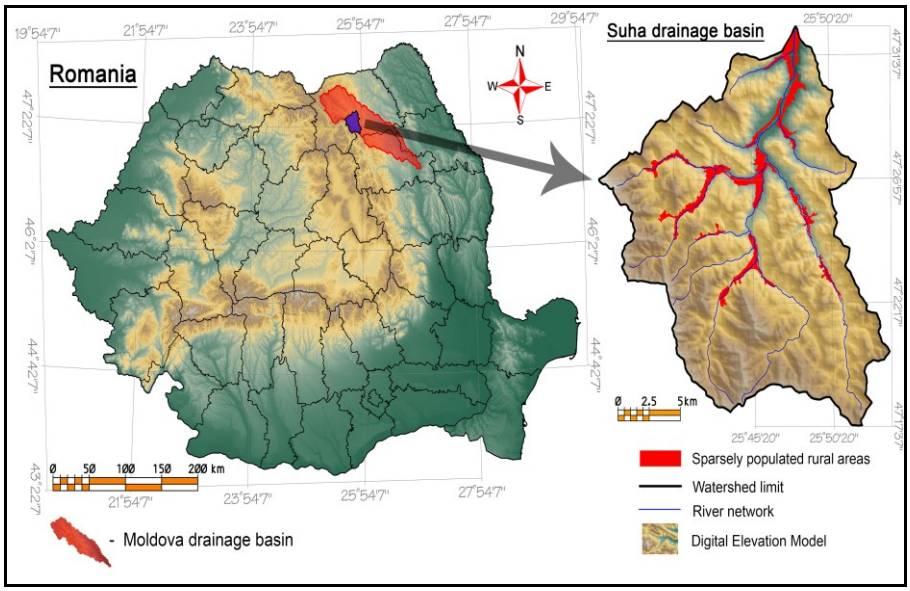

Fig. 1 Geographical position of the Suha River Basin

The problems regarding the discharge regime in the Suha basin are very important for the local population. This hydrological regime is determined by natural geographical factors (climate, geology, landforms, vegetal and soil cover) to which are added the more and more influent human influences.

2. Materials and methods

The analysis of the rainfall impact on the hydrologic regime of Suha Basin can become a basis for the hydrological prognosis which is elaborated based on the rainfall-discharge relation, and will also be an important element in determining flooding areas and identifying specific measures for flood control and defense. Knowing the rainfall quantities implies the knowledge of the minimum and maximum limits in which these might fall, the probability of some specific quantities, as well as their territorial repartition.

In the estimation of the impact of rainfalls on the hydrological regime of Suha basin have been used data obtained by the Siret-Bacău Water Basin

Administration and INHGA-Bucureşti. The following rainfall elements have been analyzed for the year of 2006: quantity, duration, intensity, tendency and effects.

3. Results and discussions

From a climatic viewpoint, Suha basin is situated in the moderate mid-latitude area of mountainous type. No matter what the position of the baric centers that condition weather states at the continental level is, local influences interfere each time and condition many particular characteristics: atmospheric circulation channeling along river valleys, thermal inversions, föhn and local winds. The general climatic background is influenced by the active surface, expressed through local morphological characteristics, vegetation and human activities.

In the Suha basin, the main local factors which come to attention are the general amphitheatre character of the landscape, with a decrease in altitudes from west (spring area) to east, from the peaks of Rarău, Ostra and Suha mountains towards the Moldova valley; the existence of several depressions and valleys with different orientations and widths which may channel the general atmospheric circulation; the presence of thermal inversions on the background of high altitude differences between the mountain summits and the low areas; the existence of some climatic „shelter" conditions in the depressions; the presence of deforestation on large areas (Ichim, 1979).

In order to analyze the impact of rainfall on discharges from 2006 in Suha Basin, we have used the database of the Siret Basin Water Administration. The observations on rainfall quantities have been conducted at three of the existing hydrometric stations in the basin: Gemenea 5 (on Slătioara river), Gemenea 2 (on Gemenea) and Stulpicani (on Suha) (Fig.2).

The main cause of flood occurence is rainfall, whose regime characteristics and spatial-temporal repartition is highly variable and discontinuous.

Due to its geographical position, Suha basin is under the influence of the baric centers that act in Europe in the area of interference of tropical and polar air masses. As a consequence, the most significant rainfall quantities have been recorded during the periods with persistent cyclonic activity and the lowest ones when anticyclonic masses have dominated (Sandu et al., 2008).

The variability of mean monthly rainfall quantities evidences significant differences during the year (Fig. 3-5). The flow rates oscillations also vary accordingly to the rainfall quantities (Fig.6)

From the analysis of mean total monthly rainfall quantities from the hydrometric stations in Suha basin it results that from February up to June-July, the monthly rainfall quantities present higher values, while towards the end of the year and in January they constantly decrease.

In June on almost the entire territory of România are measured the highest rainfall quantities during the year, frequently as heavy rains (Sandu I., 2008).

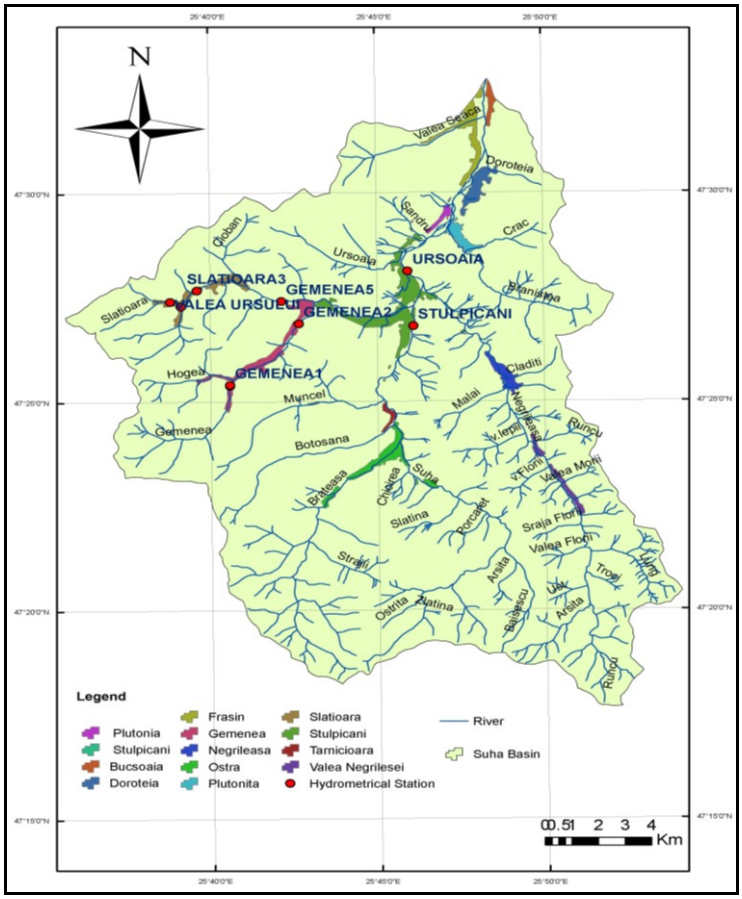

Fig. 2 Geographic position of hydrometrical stations in Suha River Basin

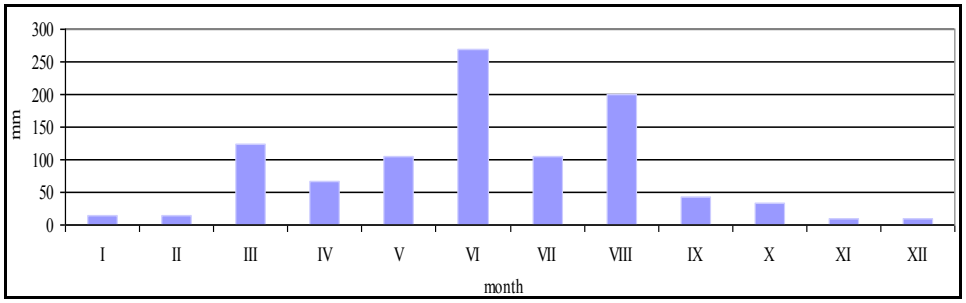

Fig. 3 Total monthly annual rainfall-2006 at Gemenea 5 hydrometric station

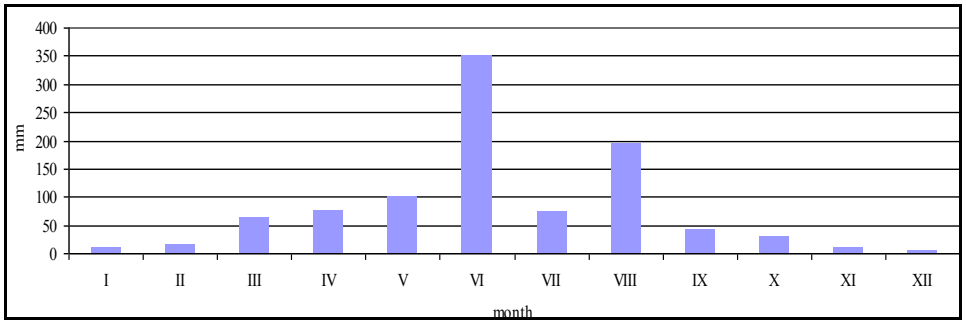

Fig.4 Total monthly annual rainfall-2006, at Stulpicani hydrometric station

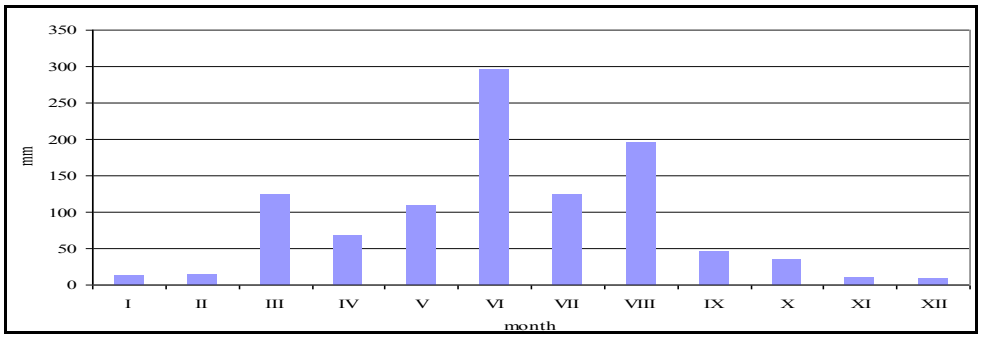

Fig. 5 Total monthly annual rainfall-2006 at Gemenea 2 hydrometric station

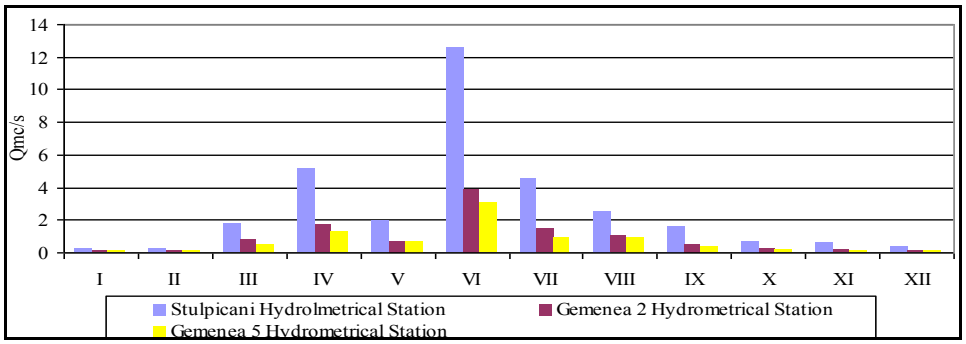

Fig. 6 Monthly average flow rates-2006

During 2006, at the country level have been registered significant rainfall quantities during June, which have caused important floods starting with the second decade and continuing up to the end of the month. Although it presents a high foresting degree, of 78%, Suha basin is characterized by frequent floods determined by local favoring factors.

The cause of these high rainfall quantities has been the one characteristic to the entire basins of Moldova and Siret rivers, namely the retrograde cyclonic movement manifested over the Eastern Carpathians during the entire month of June, amplified by local conditions.

During June 2006, the weather has been extremely hot. Mean daily temperatures have frequently exceeded 18-20ºC, and the maximum ones have reached 25-27ºC. Beginning with 02.06.2006, important rainfall quantities have started to enter the Suha basin (Fig. 3, Tab 1).

The maximum values recorded in 24 hours have been of almost 60 l/sqm at several hydrometric stations: 52.2 mm / 02.06.2006 at Gemenea 5 (on Slătioara river), 60.1 mm /02.06.2006 at Gemenea 2 (on Slătioara) and 59.0 mm /02.06.2006 at Stulpicani (on Suha).

In table 1 it can be seen that the highest rainfall quantities have been recorded at the beginning of the month. These quantities have highly contributed to soil saturation and less to significant river level increases. Lower quantities, but with higher intensities have been recorded in the second part of the month, generating important floods (Fig. 7-9).

Tab.1 Daily rainfall, June 2006

Gemenea 5 Hydr. Station	**Rainfall**	**Gemenea 2 Hydr. Station**	**Rainfall**	**Stulpicani Hydr. Station**	**Rainfall**
Date	mm	Date	mm	Date	mm
02.06.2006	33.6	02.06.2006	56.8	02.06.2006	56.2
03.06.2006	1.7	03.06.2006	1.8	03.06.2006	1.2
03.06.2006	0.6	04.06.2006	8.2	04.06.2006	22.3
04.06.2006	0.7	06.06.2006	3.3	06.06.2006	7.0
04.06.2006	20.5	07.06.2006	4.3	07.06.2006	7.4
06.06.2006	4.3	07.06.2006	8.0	10.06.2006	3.4
07.06.2006	5.0	08.06.2006	1.2	10.06.2006	1.2
07.06.2006	6.5	10.06.2006	4.7	11.06.2006	9.1
08.06.2006	1.0	10.06.2006	3.8	15.06.2006	34.3
10.06.2006	3.2	11.06.2006	11	16.06.2006	5.8
10.06.2006	2.6	14.06.2006	3.1	16.06.2006	1.1
11.06.2006	6.1	15.06.2006	39.4	18.06.2006	7.2
14.06.2006	2.9	16.06.2006	2.5	20.06.2006	6.8
15.06.2006	34.5	16.06.2006	6.1	20.06.2006	2.2
15.06.2006	1.7	18.06.2006	7.3	20.06.2006	1.9
16.06.2006	7.4	20.06.2006	7.4	21.06.2006	1.2
17.06.2006	1.3	20.06.2006	1.6	23.06.2006	16.5
18.06.2006	8.0	23.06.2006	8.8	23.06.2006	22.2
20.06.2006	4.0	23.06.2006	9.5	24.06.2006	3.0
20.06.2006	4.6	24.06.2006	9.5	25.06.2006	22.0
23.06.2006	13.7	25.06.2006	1.4	26.06.2006	12.8
24.06.2006	9.7	26.06.2006	7.5	27.06.2006	8.4
25.06.2006	1.7	27.06.2006	24.4	28.06.2006	40.8
26.06.2006	10.3	28.06.2006	9.4	30.06.2006	48.3
27.06.2006	16.7	29.06.2006	2.6		
28.06.2006	14.8	30.06.2006	18		
29.06.2006	6.0				
30.06.2006	20				

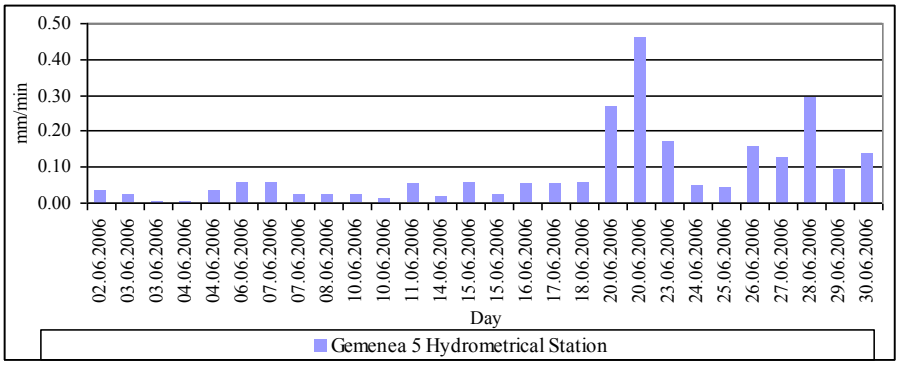

Fig. 7 Rainfall intensity in June, 2006 at Gemenea 5 hydrometric station

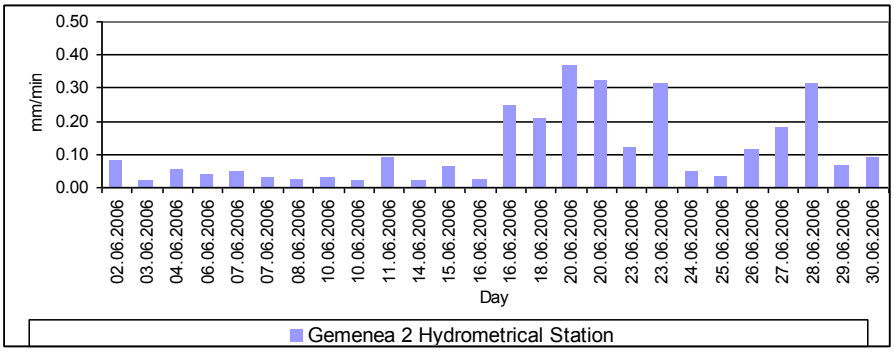

Fig.8 Rainfall intensity in June, 2006 at Gemenea 2 hydrometric station

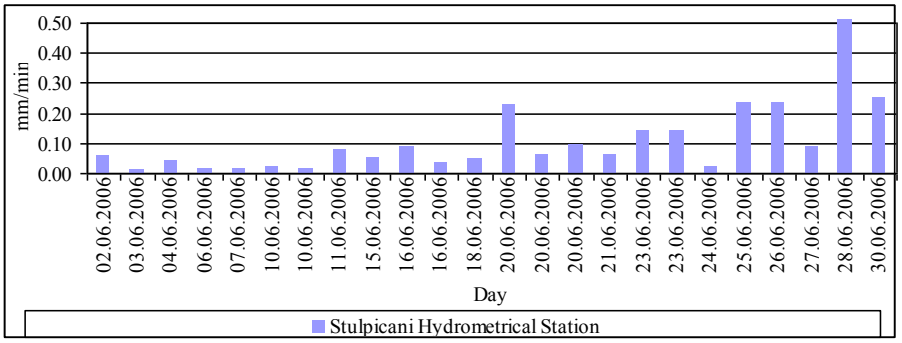

Fig. 9 Rainfall intensity in June, 2006 at Stulpicani hydrometric station

During June 16-28, 2006 rainfall has had very high intensities: 0.460 mm/min at Gemenea 5 station (on Slătioara), 0.370 mm/min at Gemenea 2 (on Gemenea) and 0.742 mm/min at Stulpicani (on Suha).

The floods have affected large surfaces of the basin, while rivers have reached maximum levels of 10 and 5% insurance. The maximum flow rates of the year have been of 84.6 m^3/s (20% insurance) on Suha at Stulpicani station, 68.9 m^3/s on Gemenea at Gemenea 2 station (being the maximum discharge ever recorded at this station and having a 2% insurance) and 38.8 m^3/s on Slătioara at Gemenea 5 (10 % insurance) (Fig. 10).

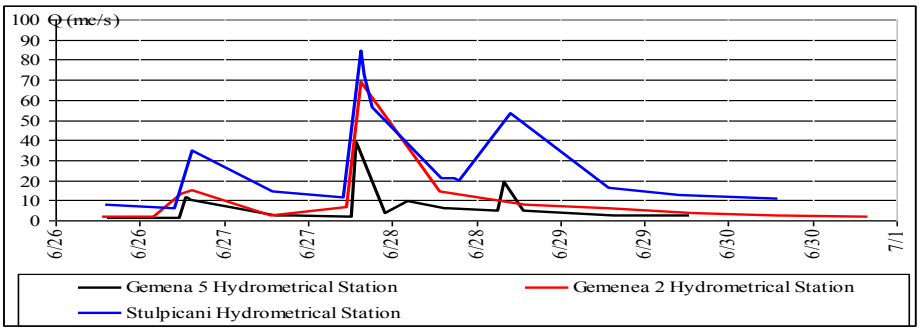

Fig. 10 Floods in Suha basin, 2006

On the background of a warm, tropical weather, a cold air front has rapidly entered from the north. The largest floods from this area are due to torrential rainfall. The negative impact is increased by the floodplain aggradation, the lack of longitudinal levees and the construction of households in the floodable area (Diaconu, 1965; Romanescu, 2003).

The devastating floods induced by the circulation of weather fronts (the retrograde circulation from the north-western part of the Black Sea) produce material and sometimes human losses. In some cases they are also the reason for large landslides. The floods occurring on certain rivers with high discharge rates (torrential) may block circulation by flooding, destroying or blocking bridges and by depositing sediments on the roads. The material losses that are produced every year sum up millions of euro, in the conditions in which the drained area is relatively reduced.

Fig. 10 Suha River (ABA Siret, 2006)

Fig. 11 Slatioara River(ABA Siret, 2006)

Fig. 12 Gemenea River (ABA Siret, 2006)

Fig. 13 Gemenea River (ABA Siret, 2006)

According to the report of Siret- Bacau, during June 4-28, 2006 damages and losses have been signaled in all localities from Suha basin. In the town of Frasin have been destroyed three households, one socio-cultural building, 7 bridges, 0.8 km of national road blocked by sediments, 0.96 km of bank protecting works and two flooded fountains. In Ostra township have been affected 0.15 km of county road, while in Stulpicani township (Negrileasa and Gemenea villages) have been affected 10 houses, 1 concrete bridge whose retaining walls have been destroyed, 1 bridge, 0.05 km of the 32 commune road, 1.6 km of the longitudinal levee on Negrileasa broook.

Conclusions

Suha Basin is a middle-sized one and has a hydrological behavior which depends on the rainfall quantity and intensity. The year of 2006 has been characterized by high rainfall quantities which have generated significant increases in river discharge rates. The absolute maximum value recorded in 24 hours has been of over 50 mm. beginning with the second decade of June have been recorded high rainfall intensities: 0.460 mm/min at Gemenea 5 station (on Slătioara), 0.370 mm/min at Gemenea 2 (on Gemenea) and 0.742 mm/min at Stulpicani (on Suha). These intensities have generated the floods that have affected large areas of the basin, and the rivers have reached maximum levels with 10 and 5% insurance rates.

The creation of hydrological prognosis based on the detailed analysis of the rainfall role in the discharge process is extremely important.

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ATMOSPHERIC PATTERNS DURING THE STORMS FROM JANUARY 2014 IN BULGARIA AND ROMANIA

Brindusa Chiotoroiu[1], Veneta Ivanova[2], Liviu Apostol[3]

Key words : storms, Bulgaria, Romania, synoptic conditions, model outputs.

Abstract. Synoptic conditions associated with strong winds and snowfalls on January 2014 in Bulgaria and Romania are investigated in this paper. The Romanian authorities established the orange and red codes while the Bulgarian ones the orange code. A first peak was recorded in northern and especially north-eastern Bulgaria and south-eastern Romania on January 25-26 and a second one on January 29 2014. The purpose is to understand what regulates the duration and intensity of these events. For their study, NCEP-500/700/850 and SLP analyses, different model outputs and soundings as well as data from 12 weather stations have been used.

Introduction

When associated with drifting snow, strong winds have grave consequences on transports, infrastructure, electricity supply etc. in Bulgaria and Romania. Strong winds in the south-eastern parts of Romania and north-eastern parts of Bulgaria occur in winter during synoptic conditions described as "the coupling" continental anticyclone/Mediterranean cyclone arriving over the Black Sea.

Climatological studies showed that more than half of all the storms in the region occur during such synoptic conditions and that the dominant wind direction is north or north-east (Valchev et al., 2012; Chiotoroiu, 1999). Cold air is brought to low latitudes due to an important amplification of the planetary-scale flow waves during the development phase of the Mediterranean cyclones (Georgescu et al., 2009; Maheras et al., 2001; Tayanc et al., 1998). Heavy

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precipitations over Bulgaria and Romania are connected to the observed paths of the cyclones (Apostol, 2008; Bocheva et al., 2007). At 1000 hPa an elongated minimum core distributed between the Aegean and Black seas, beneath the upper-trough was observed using the composites of geopotential height (Trigo, 2002). The south-east part of Romania is generally characterised by the presence of thermal inversions, with the cold air prevailing at ground level (ENE winds) and the warm air at 900-850 hPa (SSE winds), Draghici et al., 1990. Unexpected heavy snowstorms in the western and south-western parts of the Black sea are related with sea-surface 850 hPa temperature differences and with sea-land temperatures differences (Kindap, 2010). Blizzards and cold waves in the eastern and south-eastern parts of Romania and north-eastern Bulgaria are due to this interaction between a continental anticyclone and a Mediterranean cyclone (Chiotoroiu et al., 2013; Ionac et al., 2012; Georgescu et al., 2009; Cordoneanu, 2004; Georgescu et al., 2004; Capsa and Timofte, 2005; Popa and Soci, 2002; Latinov and Nikolov, 2001; Latinov, 2001).

During the period between the 25 and the 30 of January 2014 many local roads were closed and some regions witnessed power outages in the south-east part of Romania. Traffic on highways and sections of 27 national roads was closed. Inhabitants from several villages in the counties of Braila, Buzau, Galati remained isolated due to snowfall. O**ver 160 trains were cancelled,** traffic restrictions being introduced for many railway lines. T**he maritime ports of** Midia, Constanta North, Constanta South Agigea and Mangalia were closed on 26 January because of the strong wind; also transport activities on the Danube – Black Sea and Sulina – Bara Sulina canals were suspended (http://www.euronews.com/2014/01/29/...).

In the Bulgarian regions of Ruse, Silistra, Razgrad, Targovishte and Dobrich many roads were closed between the 24 and 26 of January 2014 when strong winds formed snowdrifts. Roads became icy in Varna and Burgas on January 26 because of the heavy rain and the cold spell. Few villages in the regions of Shabla, Kavarna and Dobrich from the north-eastern part of Bulgaria were without electricity because of icy or broken electrical cables. The maritime ports of Varna and Burgas were closed from the 24 to the 27 of January and again from the 28 to the 30 of January. Bridges over the Danube were also closed during this period.

National committees for emergency situations have been created in Bulgaria and Romania and appropriate regulations have been adopted in order to prevent damages and protect population during natural disasters. The population is informed about the weather phenomena and the risks involved through the mass media, internet or by calling telephone numbers provided by

the national authorities. The main information about the intensity of the phenomena is provided by the meteorological warnings.

The main purpose of this paper is the analysis of the genesis conditions and of the weather characteristics during these storms using GFS and Aladin model outputs, soundings and data from the weather stations.

1. The meteorological warnings.

The storms from January 2014 were considered by the Romanian authorities as dangerous phenomena and orange and red codes* were issued by the meteorological administration.

**Orange and red codes meaning is:*

"dangerous weather phenomena of high intensity are forecast (wind, heavy rainfall, electrical discharges, hail, hot weather, extreme cold). There is a risk of flood on small rivers)" and "extremely violent and dangerous weather phenomena are forecast (wind, heavy rainfall, thunderstorms, hail, hot weather, extreme cold). There is a risk of major floods" respectively.

The orange code was issued starting with the 25 of January, first at 5 a.m. local time only for the northern part of the Olt county (OT on the map) and afterwards for almost all the south-eastern part of Romania (fig. 1). This warning was valid until the 26 of January at 22 p.m., local time. The main weather phenomena forecast were: wind gusts over 70–80 km/h, drifting snow and visibility less than 50 m (http://www.agerpres.ro/news-of-the-day/2014/01/26/...).

Issuing a Code Red in Romania requires several cumulative conditions, including the risk of impossible circulation on roads, railways, by air or by water, villages risk being secluded, and the lives of villagers are endangered, as well as possible damages to forests and electrical networks. On January 26 2014 the meteorological phenomena became extremely violent and the Romanian meteorological administration decided to adopt the red code from 3 p.m. to 9 p.m. This warning concerned only a restricted area covering the department of Buzau (BZ), the south part of the Vrancea county (VN) and the north part of the Braila county (BR). The forecast referred to: heavy snowfall, blizzard and drifting snow, visibility almost zero, wind gusts that can exceed 70-80 km/h; at 13 h (on January 26 2014) the snow cover was about 40 cm and the blizzard had a continuous duration of 36 hours (fig. 2). Another orange code was issued on January 29, the warning concerned many counties in the south-east Romania (http://ercportal.jrc.ec.europa.eu/ECHO-Flash/...).

In Bulgaria the orange code** was adopted for all the 15 regions from the north and east parts of Bulgaria (fig. 1). The weather phenomena forecast were: snow cover of 15-25 cm, strong east winds, risk of blizzard and snowdrifts; in

the districts of Dobrich, Varna and Burgas east winds will reach 25-30 m/s (over 90 km/h); rainfall amounts could reach 15-20 mm.

***The Bulgarian definitions follow the Meteoalarm ones (Fuchedziev et al., 1981). The orange code means: "the weather is dangerous. Unusual weather phenomena have been forecast. Damage and casualties are likely to happen. Be very vigilant and keep regularly informed about the detailed expected meteorological conditions. Be aware of the risks that might be unavoidable. Follow any advice given by your authorities".*

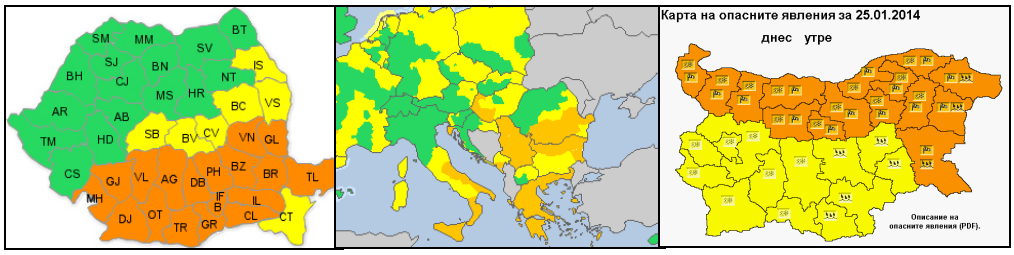

Fig. 1. Warnings of the Romanian Meteorological Administration (left), Meteoalarm (centre) and of the Bulgarian Institute of Meteorology and Hydrology (right), starting with 25.01.2014

2. The synoptic conditions.

The development of a low pressure area over Italy and the extension of a high pressure field over the north-east of Europe were the main characteristics of the atmospheric circulation in the low troposphere on January 24 2014. The presence of a trough at 500 hPa enhanced the development of the Mediterranean cyclone (fig. 2).

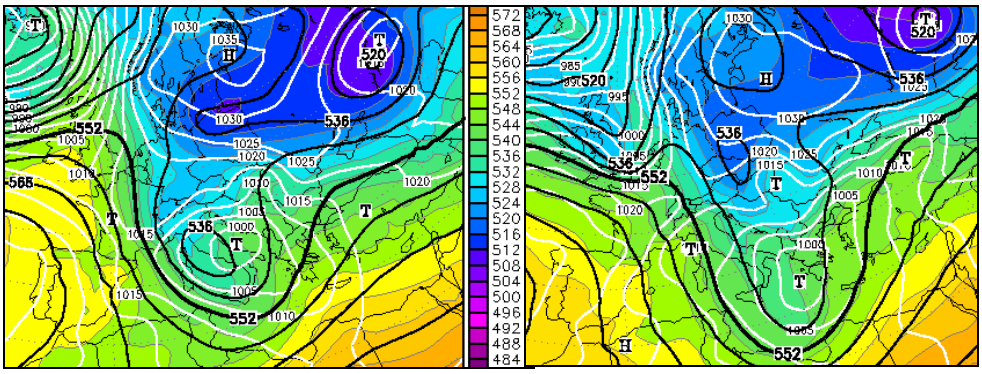

Fig. 2. Sea level pressure, 500 hPa geopotential and relative topography H500-H1000, GFS analysis, January 2014 24, 18 UTC (left) and 25, 18 UTC (right), www.wetter3.de

In the middle troposphere the flow was from southwest the 24 and from south the 25 of January, while surface winds blew from east-northeast on 24 and from north-east the 25 when they became very strong (fig. 3). Their opposite directions explain the cloudiness and precipitations on January 24: snow in the weather stations located on the cold side of the warm front and rain in other stations (including the coastal area).

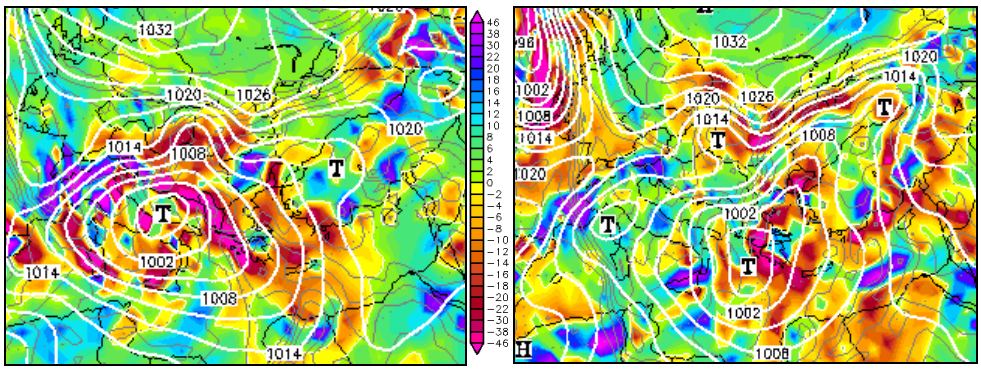

Fig. 3. Sea level pressure (hPa), 700 hPa vertical movements, 850 hPa frontal zones,January 2014 24, 18 UTC (left) and 25, 18 UTC (right), www.wetter3.de

The precipitations' type and intensity can be better observed on the approximate soundings for Dobrich (Bulgaria) and Buzau (Romania), fig. 4. On January 24, at 18 UTC the inversion layer was thicker over Buzau (Romania). Air temperature and dew point lines were on the left side of isotherm zero while for Dobrich they were over it. The air above 700 hPa was not so saturated. Stratus clouds formed so precipitations were slight. Vertical wind shear clearly appears and shows slight warm advection above 850 hPa. At 700 hPa the upward vertical movements became very intense over Macedonia (up to -38 hPa/h). East-northeast winds at ground level became stronger too.

On January 25, 12 UTC the relative humidity recorded high values at 700 hPa over Romania, north Bulgaria and northwestern Black Sea and vertical movements reached ~-20 hPa/h (fig. 3). Rain and snow falls were more important than the previous day (fig. 4).

Starting with January 26, advection of cold air from the north can be observed at 850 hPa (-10°C over Romania and -12°C over the north-western part of Bulgaria), while the air is warmer over the Black Sea (+5°C), fig. 5. The cyclone is now centered over the Peloponnesian peninsula, with pressure decreasing to 995 hPa. The circulation is meridional at 500 hPa, with a trough located over the sea-level low pressure centre. High relative humidity and

strong vertical movements at 700 hPa can be observed over eastern Bulgaria and Romania (fig. 5).

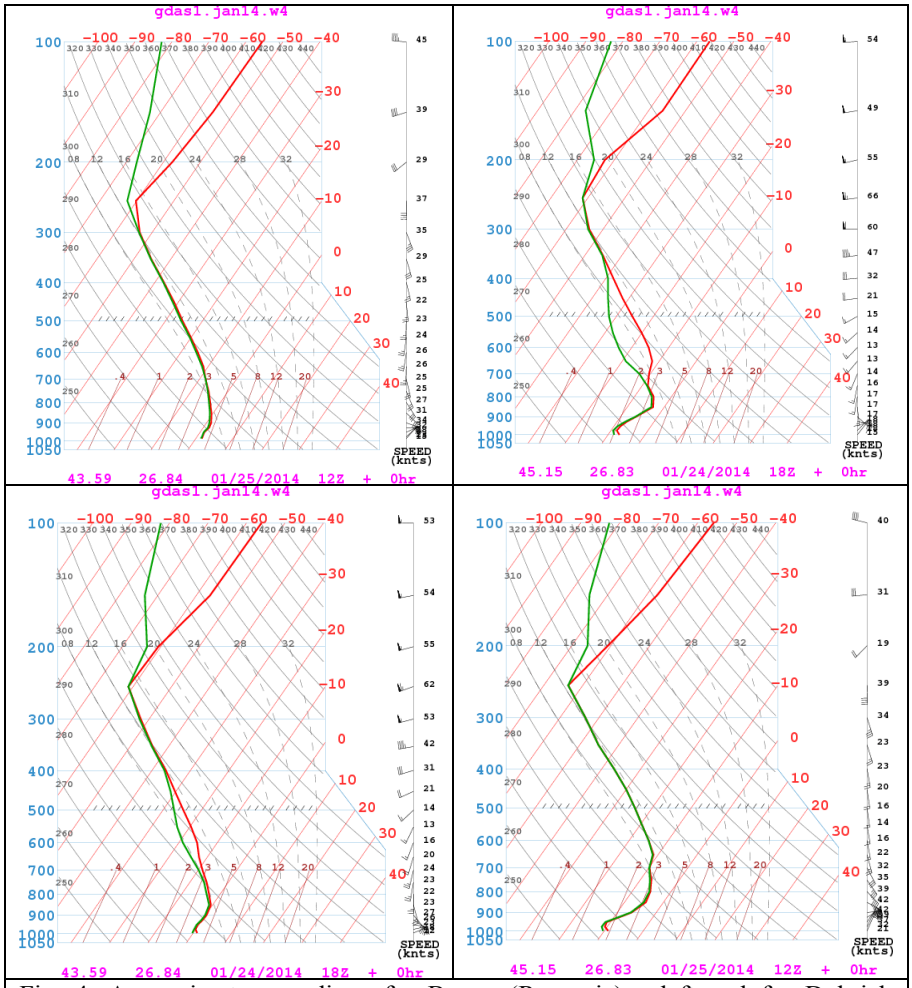

Fig. 4. Approximate soundings for Buzau (Romania) - left and for Dobrich (Bulgaria) - righton 24 .01.2014, 18 UTC (upper fig.) and 25.01.2014 (down fig.), http://ready.arl.noaa.gov

Figure 5 also shows heavy snowfalls over a large part of Bulgaria and south-east Romania. Due to the snowfalls, the snow cover quickly rised on January 25 2014 ; it reached more than 40 cm in the Romanian stations of Buzau and Galati and more than 50 cm in the station of Craiova, while in

Bulgaria the maximum height was under 40 cm in Razgrad at the end of the studied period 25 to 30.01.2014 (fig. 6). Snow covers of more than 40 cm height were recorded in other weather stations (not represented in this paper) within an area covering parts of the Romanian counties of Buzau, Vrancea and Braila. Snowdrifts were also very high here, 200 cm near Bucuresti, 260 cm in Focsani and Ramnicu Sarat (Sipos and Manta, 2014).

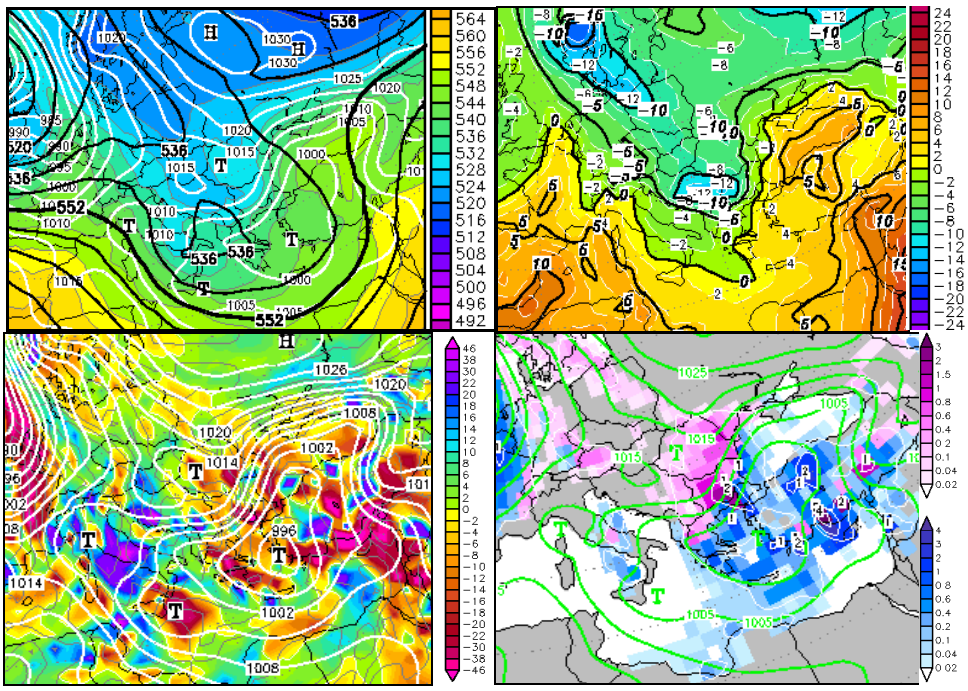

Fig. 5. Upper figures: Sea level pressure, 500 hPa geopotential and relative topography H500-H1000 (left) and temperatures at 850 hPa (right), GFS analysis; Down figures: Sea level pressure, 700 hPa vertical movements, 850 hPa frontal zones (left) and precipitations in mm/h (snow in pink, rain in blue), 6h forecast (right), GFS model; January 2014 26, 18 UTC, www.wetter3.de

Wind gusts reached more than 22.5 m/s (80 km/h) in Buzau and Sulina on January 25/26 and again on 29/30 while in Bulgaria winds over 24 m/s (86.4 km/h) only in Razgrad on January 25 and more than 21 m/s (75.5 km/h) in Shabla (on the coast) on January 29 2014 (fig. 6).

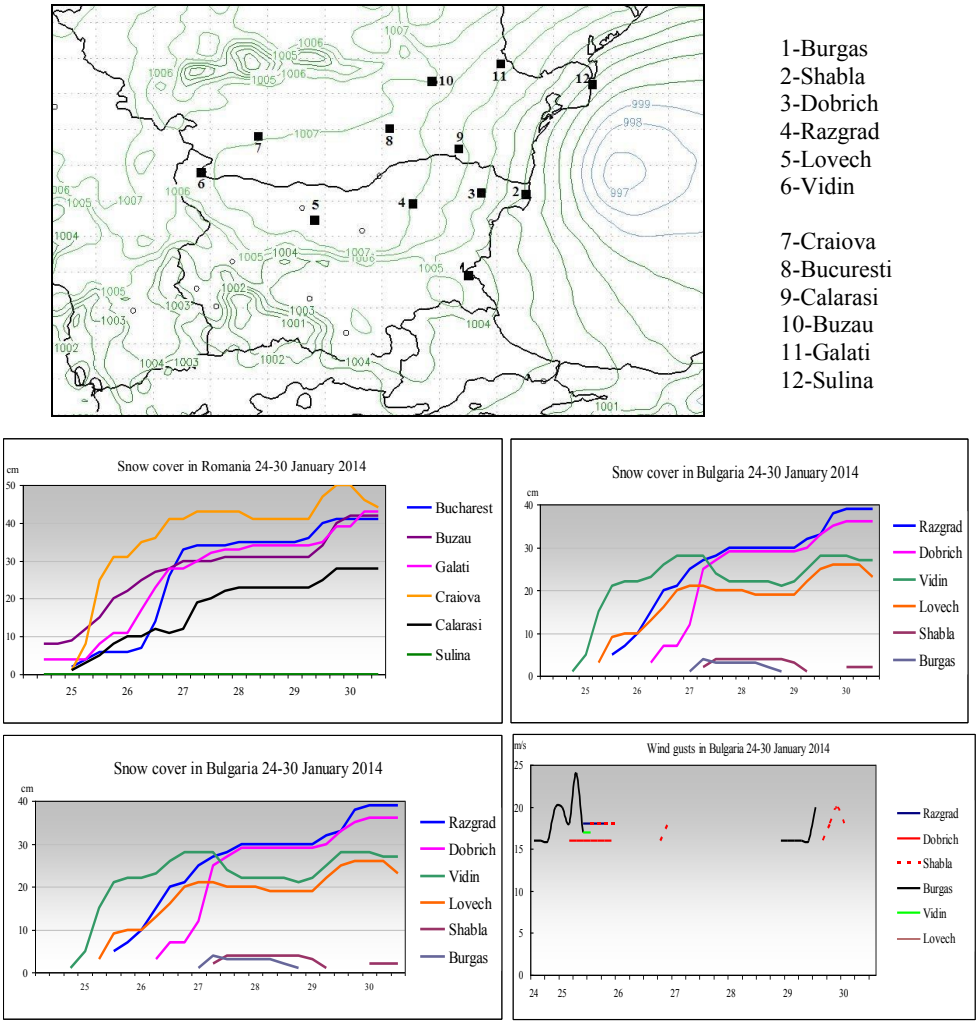

Fig. 6. Location of the weather stations (upper fig.);snow cover (cm) and wind gusts (m/s), (down figs.) The support map is from the ALADIN model output for January 27 2014, 18 UTC.

Due to its good resolution, the Aladin model has the advantage of considering the particularities of the zone for which it works. For the 25 and 26 of January 2014, the outputs show an increasing wind speed offshore the Bulgarian coasts, over the Black sea, but also in the south-east Romania, at the exterior of the Carpathians curvature (barbs of 22.5 m/s), fig. 7.

On January 27 the cyclone was located over the Black Sea, as it can be observed on the support map in figure 6, from the Aladin output from January 27, 18 UTC. Strong north-west winds blew especially over the coastal area and consequently the sea state became rough (waves height over 4 m). The 28 of January the filling of the cyclone and its movement to the north-west Black Sea, over the gulf of Odessa, can be observed.

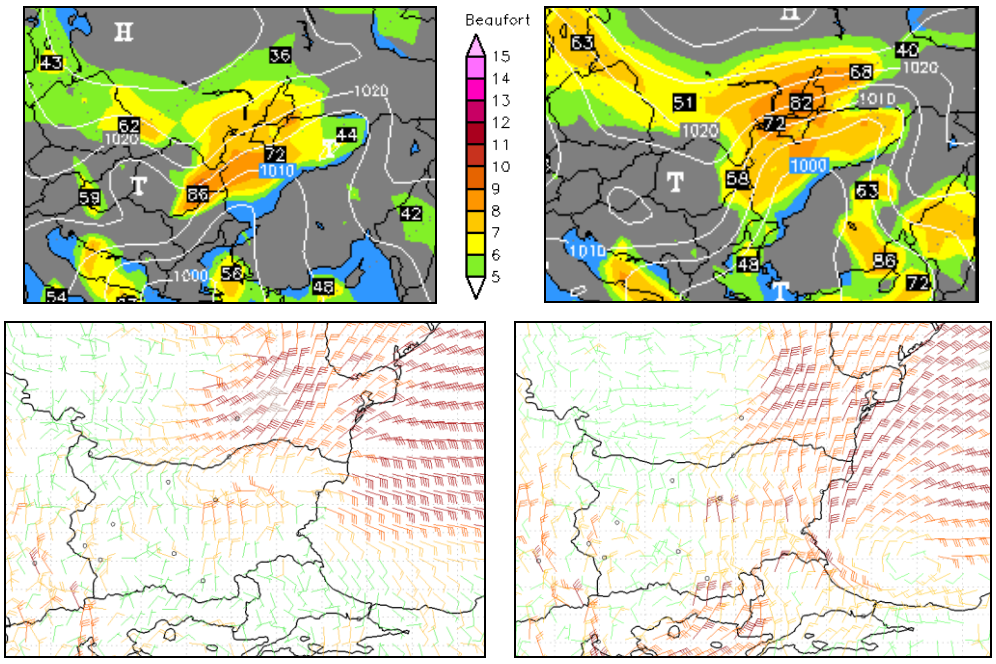

Fig. 7. Wind gusts at 10 m on January 25, 18 UTC (left) and on 26, 18 UTC (right) GFS model (upper figures) and ALADIN Bulgaria (down figures), www.wetter3.de and Bulgaria operational suite

The weather became severe again on January 29 2014 and the orange code was issued in Romania for the south-eastern part of the country. The north-east European anticyclone reinforced (1050 hPa), while a fast moving cyclone can be observed first over the Aegean sea and later on, around 18 UTC, over the Black sea (1008 hPa). Cold advections can be observed at 850 hPa, together with strong vertical movements at 700 hPa (-38 hPa/h). Rain followed by snow fell along the coasts (fig. 8). Air temperature dropped below 0°C around 15 UTC. Wind started to decrease and precipitations stopped on January 30 2014.

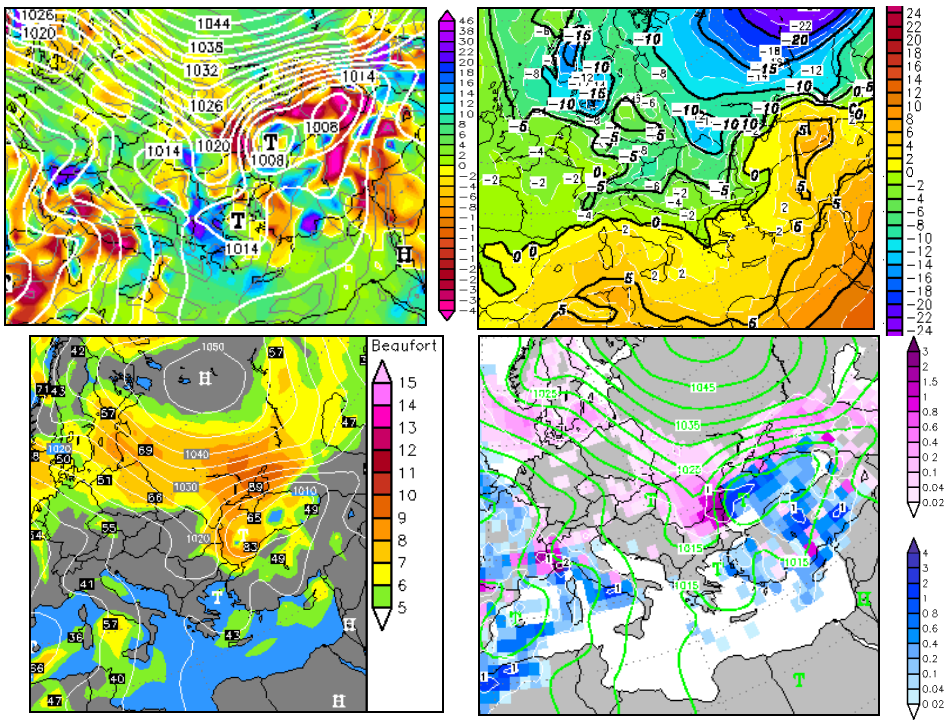

Fig. 8 *Upper figures*: Sea level pressure, 700 hPa vertical movements, 850 hPa frontal zones (left) and temperatures at 850 hPa (right); *Down figures*: Wind gusts Bft at 10 m and precipitations in mm/h (snow in pink), 6h forecast; GFS analysis, 29 Jan. 2014, 18 UTC, www.wetter3.de

Conclusions

Wind and snow storms over the south and south-eastern part of Romania and the north and north-eastern part of Bulgaria had grave consequences on the environment and the economic activities. They were generated by deep cyclones that developed over the Mediterranean Sea and moved to the Black Sea, while continental areas were dominated by high pressure systems. The development and movement of the cyclones depended on the position of the troughs, generally with large meridian extensions. In January 2014 on 25 and 26 the low pressure systems moved slowly to the Black sea, their development being sustained by the upper level trough. On 29, the second peak of strong winds was due to another Mediterranean cyclone that had a rapid movement to the Black sea. Sea-surface 850 hPa temperature differences and sea-land temperatures differences were important during these winter storms.

Acknowledgements: The warning maps are from the meteoalarm.eu website and from media. The GFS analysis and forecast maps were downloaded from www.wetter3.de archive. Wind speed and snow cover data recorded at the weather stations have been extracted from www.ogimet.com. The atmospheric soundings have been downloaded from http://ready.arl.noaa.gov and the Aladin model outputs are from the National Bulgarian Institute of Meteorology and Hydrology. Websites were accessed in January 2014.

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***http://www.meteoalarm.eu

***www.ogimet.com

***http://ready.arl.noaa.gov

***www.wetter3.de

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THE WIND REGIME IN THE CRIŞUL NEGRU HYDROGRAPHIC BASIN

Galiş Viorel[1]

Key words: wind regime, Crişul Negru hydrographic basin

Abstract. The paper presents the main features of the wind regime in the Crişul Negru hydrographic basin starting from meteorological data recorded at 10 stations distributed across the basin. The analysis was developed based on the classical methodology of processing the meteorological data presented with a climatological purpose in various specialty studies. The study developed reveals that the wind regime depends on a number of factors such as the air movement, topography and local conditions, actually known from previous studies, but this paper distinguishes itself as a novelty through its values that are statistically concrete and correct, all calculated for the main parameters.

Introduction

Just like precipitations, the wind is highly variable in time and space and is a consequence of the different heating of land and / or water that generates air masses with different thermal and baric characteristics.

In the hydrographic basin Crişul Negru, the wind regime is strongly influenced by the presence of the three steps of relief arranged in amphitheater, by the atmospheric circulation and by the local topography which greatly alters the wind speed and direction and fosters the development of local circulation.

1. History of research

Up to present no complex and complete climatic study has been conducted on the Crişul Negru hydrographic basin (Măhăra and co., 1999 Moza, 2009), so there is only information about the study of wider areas. Among these we mention the doctoral dissertations published by: Cristea (2004) which marks the climate risks from the Criş basin and which mentions certain climatic elements, including wind,

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all analyzed using data from several weather stations in the Crişul Negru hydrographic basin; Gaceu (2005) who analyzes a double period (40 years) and refers to climate and climate risks in Vlădeasa and Bihor Mountains, including the wind regime, a more detailed and highly parameterized analysis but which focuses less on our study area (with the weather stations form Stâna de Vale and Ştei); Şerban (2010) who, through a detailed analysis, refers to climate hazards from the Western Plain which is located north of Mureş and captures through the Salonta, Holod, Chişinău Criş, Ineu stations aspects concerning wind.

Climatic aspects concerning the wind regime from the Crişul Negru hydrographic basin were presented in other articles: Măhăra, Linc, 1993; Gaceu, 1997; Dragotă, Gaceu, 2002, 2004; Gaceu, 2004; Gaceu, 2009.. Some references to the Crişul Negru hydrographic basin climate appear in the following works: ***, 1960 *** 1961 *** 1962 *** 1966; *** 1966 b; *** 1972-1979 * ** 1983 *** 1987 *** 2005; Gaceu and co., 2002, 2003, Măhăra and co. 1999; Bogdan, Niculescu, 1999

2. Data and metodology

The Crişul Negru hydrographic basin covers all three levels of relief (plains, hills, mountains), an aspect considered when selecting the weather stations for a better measurement of air temperature characteristics . Thus, we chose 10 meteorological stations (Fig. 1) distributed as follows: Vlădeasa (1836 m), Stâna de Vale (1108 m), Zece Hotare (642 m), Moneasa (703 m) for the mountain area Dumbrăviţa de Codru (586 m), Ştei (278 m) for the hilly area , Holod (163 m), Salonta (95 m), Chişineu Criş (96 m), Ineu (110 m). Unfortunately, the climate analysis was more difficult due to the lack of homogeneity of the data, the stations being set up in different stages, during the (1959 – Ştei, 1961 – Vlădeasa 1800, 1962 – Chişineu Criş, 1967 - Holod), the 1970's 1970 (1975 – Moneasa, 1979 – Stâna de Vale and Ineu), anii 1980 (1983 – Dumbrăviţa de Codru and Salonta), the 2000's (Zece Hotare, Moneasa, Salonta, Ineu), which is why we used data from the 1978-2007 period , a continuum 30 years , thus respecting the climate research methodology.

Due to the process started in Romania in the 2000's to dispense with the weather stations (the question of the automation and computerization of the National Meteorological system arose) 4 of the 10 stations in the Crişul Negru basin (Zece Hotare, Moneasa, Salonta, Ineu) have 7 years short data, but the remaining 6 stations (Vlădeasa 1800, Stâna de Vale, Ştei, Dumbrăviţa de Codru, Holod, Chişineu Criş) have continuous data for 30 years so they are representative according to the WMO norms and are uniformly distributed on the surface of the studied basin (Kostin, Pokrovskaia, 1964; Belozerov, Fărcaş, 1971; Arlery et. al., 1973; Marin, 1986; Fărcaş, 1988; Bogdan, Niculescu, 1999; Gaceu, 2002).

Thus, we tried to conduct a comparative analysis as objective as possible, which is why we used pure data, without interfering with statistical processing which can sometimes drift away from the factual reality, a goal accomplished due to the existence of six meteorological stations with data complete for 30 years.

3. Results and debates

3.1. Frequency of wind on cardinal directions

3.1.1. The annual average frequency of the wind on cardinal directions. Compiling and analyzing the annual wind rose for each station has highlighted the main wind direction and the sectors in which it blows less often. As already known, the wind direction is not influenced at high altitudes, but with decreasing altitude, and the occurrence of friction it is changed. Thus, at Vlădeasa the wind blows generally according to the general atmospheric circulation in the western sector, with a frequency of 40.4%, but at lower altitudes topography shows its influence: Stâna de Vale, a station cramped in a small depression, recorded just 6.9% in west, Ştei just 1.7%, 1.7%, Dumbrăviţa de Codru 6.4%, Zece Hotare 2.1%, Moneasa 9.6%, Ineu 5.5%, Chişineu Criş 4.4%, Salonta 5.2% (Table 1, Fig. 2).

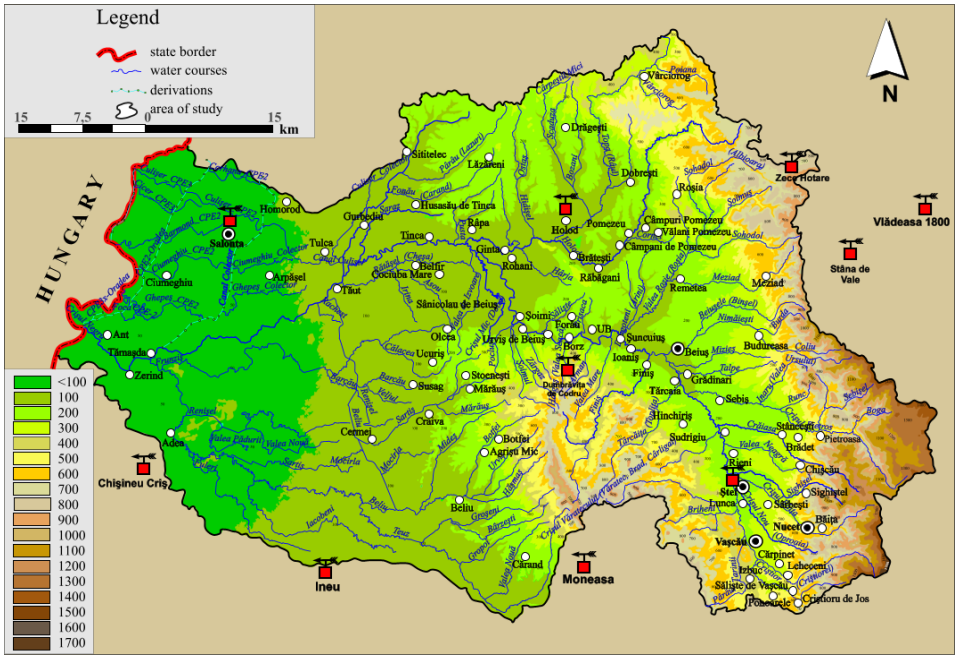

Fig. 1. The location of the meteorological stations in the Crişul Negru hydrographic basin.

We have to note that the value registered in a westerly direction at Stâna de Vale (6.9%) is still high, the highest frequency on cardinal directions taking into consideration the calm winds is the most frequent in this place (75.3%) (Table 1, Fig. 2).

In the case of the other stations located at lower altitudes, the wind recorded higher frequencies in the northern sector (14.1% at Salonta, 13.0% at Chişineu Criş, 9.2% at Ineu) and in the southern sector (33.0% at Ştei, 14 9% at Dumbrăviţa de Codru, 20.8% at Zece Hotare, 5.7% at Moneasa) than in the western one, as it would be normal according to latitudinal movements, but these differences highlight once again the influence of topography (Table 1, Fig. 2).

Tab. .1 The annual average wind frequency (%) and speed (m / s) on cardinal directions in the Crişul Negru hydrographic basin

Station		Vlădeasa	Stâna de Vale	Moneasa	Zece Hotare	Dumbrăviţa de Codru	Ştei	Holod	Ineu	Chişineu Criş	Salonta
Medium frequency (%)	N	3.2	1.1	4.1	4.1	3.3	4.6	13.2	9.2	13.0	14.1
	NE	3.8	1.3	1.5	9.1	4.4	1.0	13.2	2.6	4.1	10.4
	E	10.8	2.6	5.1	6.6	6.3	0.9	10.8	7.3	5.9	4.2
	SE	7.0	5.1	5,1	3.1	6.2	6.5	2.1	6.8	6.4	5.7
	S	4.0	2.1	5.7	20.8	14.9	33.0	2.6	8.7	11.8	11.3
	SV	14.5	1.8	9.8	12.1	17.6	5.1	10.7	8.9	9.6	7.0
	V	40.4	6.9	9.6	2.1	6.4	1.7	9.0	5.5	4.4	5.2
	NV	5.5	3.8	5.6	1.6	2.5	8.6	4.0	5.2	4.5	4.6
Calm		10.7	75.3	52.9	39.6	38.4	42.6	31.5	45.8	40.3	37.5
Medium speed (m/s)	N	2.6	2.3	2.9	3.3	2.4	3.0	3.0	2.9	3.5	2.9
	NE	2.7	2.6	2.5	3.0	2.2	3.1	2.4	2.1	3.1	2.7
	E	3.6	2.8	2.7	2.5	2.4	2.5	2.2	2.1	2.4	2.1
	SE	3.1	2.7	2.5	2.2	2.9	3.4	2.4	2.8	2.5	2.2
	S	2.5	2.7	2.1	3.6	3.5	3.3	3.3	3.3	4.0	3.5
	SV	4.2	2.6	1.9	4.1	3.3	3.3	3.5	3.0	3.9	3.4
	V	5.7	2.3	1.9	3.6	2.6	2.8	3.0	2.7	3.5	3.3
	NV	3.1	2.2	2.4	3.0	2.0	3.4	2.7	2.6	3.4	2.8

Source: Data from the A.N.M. Archives

Just like in the case of the annual values, the same directions of the wind are valid for the representative months of the year, which certifies once again that the local morphology is more important in setting the direction from which the wind blows that the general circulation of the atmosphere.

Thus, at Vlădeasa, at over 1800 m altitude, the wind blows predominantly from the west with a maximum in December (45.9%) and a minimum in May (33.2%) (Table 2, Fig. 3).

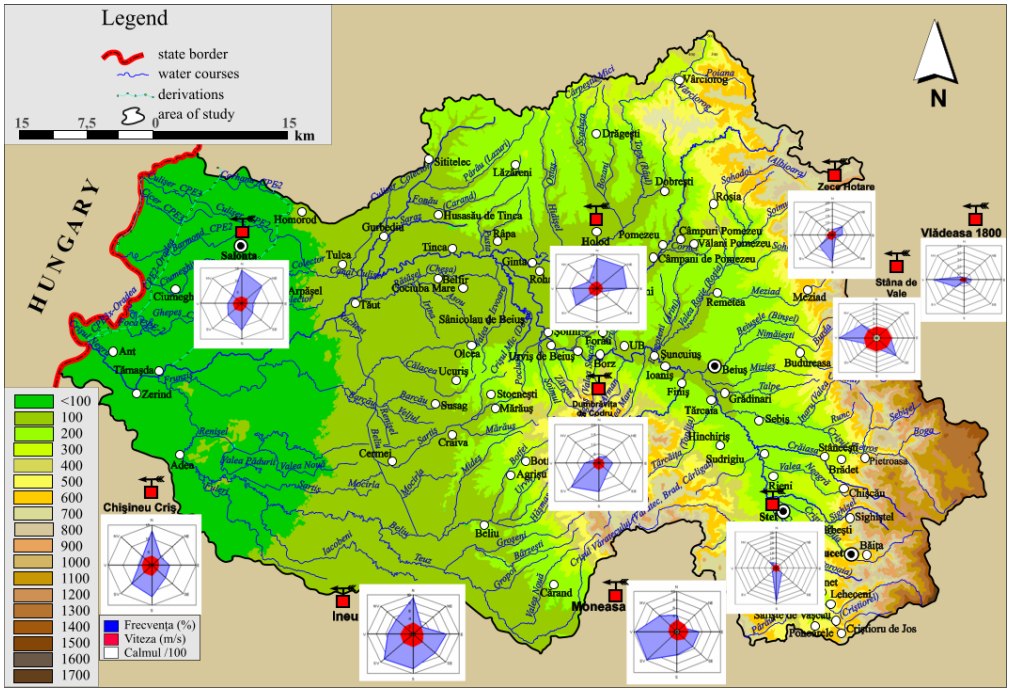

Fig. 2. The annual wind roses in the Crişul Negru hydrographic basin.

3.1.2. The monthly average frequency (%) of the wind on the cardinal directions. Moreover, the other stations keep the same characteristic: Stâna de Vale recorded the highest frequency of the wind in September in the western sector with 8.8% of the cases, at Ştei the wind blows from south more often in November, with a high frequency range between 36.1% in November and 25.8% in July, etc. (Table 2, Fig. 3).

The lowest monthly frequency of the wind direction in the the Crişul Negru hydrographic basin occurs in the winter months, with 1.9% in the southeastern sector at Vlădeasa in November, 0.5% at Stâna de Vale in December in the northern sector, 0. 4% at Ştei in December in the eastern and north-eastern sector etc. (Table 2, Fig. 3).

Tab. 2. *The monthly and annual average of calm winds and wind (%) at several stations from the Crişul Negru hydrographic basin*

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Station/direction	VLĂDEASA												
N	3.7	3.5	2.9	3.0	3.4	3.4	4.7	3.3	2.5	2.4	2.5	2.8	3.2
NE	3.9	4.2	2.9	4.6	4.8	4.8	5.4	4.8	2.4	3.4	1.9	2.9	3.8
E	9.9	7.7	9.8	14.0	16.3	12.4	13.1	13.3	10.2	8.9	6.2	7.9	10.8
SE	6.9	7.9	8.9	7.9	8.3	5.5	4.4	6.3	5.5	7.4	7.2	7.9	7.0
S	3.6	4.3	3.9	5.0	3.8	2.6	3.1	3.5	4.4	5.2	5.2	3.9	4.0
SV	14.0	14.2	15.9	16.4	14.0	11.0	10.0	12.0	15.7	16.4	19.5	15.0	14.5
V	44.1	43.3	41.1	35.8	33.2	39.3	41.2	35.2	42.5	39.0	43.8	45.9	40.4
NV	5.2	5.8	5.1	4.8	5.0	7.9	7.4	6.0	4.7	4.3	5.1	5.3	5.5
Calm	8.7	9.0	9.6	8.5	11.3	13.1	10.8	15.5	12.1	13.0	8.5	8.3	10.7
Station/direction	STÂNA DE VALE												
N	1.3	1.5	1.5	1.3	1.3	1.1	0.8	0.7	0.5	1.2	0.9	0.5	1.1
NE	1.6	1.8	2.2	1.6	1.9	1.2	1.3	0.7	0.8	0.8	1.2	0.8	1.3
E	2.3	3.6	3.1	4.2	3.8	1.7	1.2	1.3	1.7	2.5	3.1	2.9	2.6
SE	4.5	6.3	6.2	8.2	5.1	2.7	2.3	2.2	3.3	6.2	7.2	6.5	5.1
S	2.7	1.8	3.3	1.8	1.6	1.4	1.5	1.2	1.3	2.9	2.7	3.0	2.1
SV	1.5	2.1	2.0	2.1	1.5	1.6	1.7	1.2	2.0	1.5	3.1	1.6	1.8
V	5.7	5.9	7.5	6.6	6.6	8.2	7.2	8.1	8.6	7.7	6.5	4.4	6.9
NV	2.9	3.5	4.5	4.2	4.3	4.8	5.6	5.2	4.2	3.5	2.1	1.3	3.8
Calm	77.5	73.5	69.6	70.0	73.9	77.3	78.4	79.4	77.6	73.7	74.2	79.0	75.3
Station/direction	ŞTEI												
N	3.2	4.6	5.8	5.7	5.5	5.6	6.0	5.4	4.1	3.6	3.2	3.0	4.6
NE	0.9	1.3	1.4	1.0	1.1	1.3	1.5	1.1	0.8	0.5	0.5	0.4	1.0
E	0.6	1.1	0.9	1.4	1.3	1.1	1.2	1.0	0.8	0.6	0.7	0.4	0.9
SE	8.7	8.0	5.9	6.7	5.6	5.4	5.0	4.2	5.4	8.0	8.7	9.2	6.7
S	33.4	32.7	30.1	29.1	28.4	27.2	25.8	26.9	32.0	35.7	36.1	33.5	30.9
SV	1.6	2.1	3.7	3.7	3.7	3.5	3.1	3.2	3.3	3.2	3.2	1.9	3.0
V	1.3	1.0	1.6	1.9	2.6	2.4	2.1	2.0	1.7	1.3	1.2	0.9	1.7
NV	5.8	8.3	9.9	10.9	10.2	11.3	10.6	9.6	7.7	7.2	6.4	5.2	8.6
Calm	44.5	40.9	40.7	39.6	41.6	42.2	44.7	46.6	44.2	39.9	40.0	45.5	42.6

Source: Data from the A.N.M. Archives.

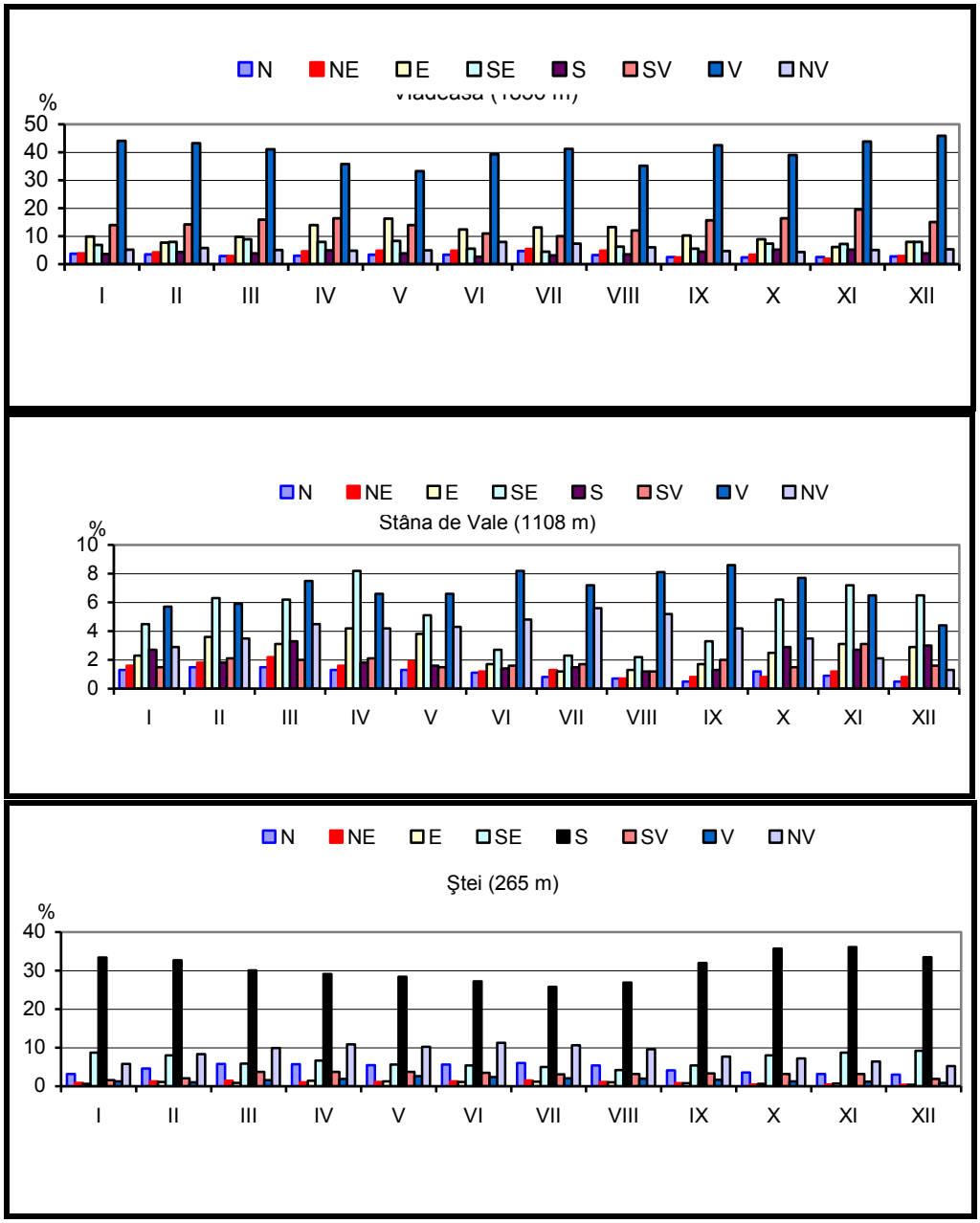

Fig. 3. The monthly frequency of the wind (%) on directions for several stations from the Crişul Negru hydrographic basin.

3.1.3. Calm winds. Looking at the annual frequency of the calm winds (Fig. 1, Table 1), we find that it has high values between 10,7% at Vlădeasa and 75,3% at Stâna de Vale. Generally, the calm winds have quite high values in the Crişul Negru hydrographic basin, especially at medium and low altitudes, due to the sheltered position of the representative meteorological stations, located in narrow depressions or due to higher friction in the case of the field area stations: 37.5% at Salonta, 40.3% at Chişineu Criş, 45.8% at Ineu. The lowest annual frequencies for calm winds occur on the heights of the Crişul Negru hydrographic basin represented by the meteorological station Vlădeasa (10.7%).

During the year *calm winds* usually recorded higher values in late summer and early autumn, when over our country lies the ridge of the Azoric anticyclone, which brings stable weather. Thus, at the greatest heights of Vlădeasa calm winds have a higher rate in August (15.5%), which also happens at Stâna de Vale (79.4% in August), Ştei (46.6% in August) and so on (Table 2, Fig. 3, Fig. 4).

The lowest monthly values of calm winds are recorded throughout the Crişul Negru hydrographic basin during spring when the atmospheric circulation changes and the thermal contrast between land and water and between different parts of the land is higher, which leads to the destabilization of the air, thus reducing the atmospheric calm values: 8.5% at Vlădeasa in April, 69.6% at Stâna de Vale in March, 39.6% at Ştei in April etc. (Table 2, Fig. 3, Fig. 4).

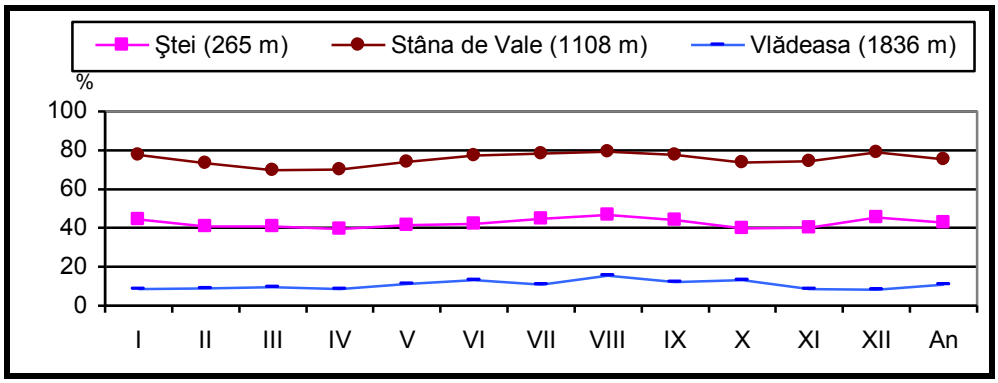

Fig. 4. The monthly frequency of calm winds (%) for several stations from the Crişul Negru hydrographic basin.

3.2. Wind speed on cardinal directions

3.2.1. The annual average wind speed on the cardinal directions. The *highest annual average wind speeds* in the the Crişul Negru hydrographic basin, are recorded in western mountain areas, at the highest altitudes: 5.7 m/s at Vlădeasa

and southern and in the southern field and hill areas: 3.5 m/s at Salonta, 4.0 m/s at Chişineu Criş, 3.3 m/s at Ineu and 3.5 m/s at Dumbrăviţa de Codru. Only the stations Ştei, Stâna de Vale and Moneasa, with special topography, record maximum speeds on the other direction, namely south-east: 2.8 m/s at Stâna de Vale, 2.5 m/s at Moneasa, 3.4 m/s at Ştei.

The *lowest annual average speeds on cardinal directions* in the Crişul Negru hydrographic basin occur on eastern direction in the fields area: 2.1 m/s at Salonta, 2.4 m/s at Chişineu Criş, 2.1 m/s at Ineu and 2.2 m/s at Holod, and on the southern direction at the highest points: 2.5 m/s at Vlădeasa. The meteorological stations located in special local conditions, respectively in the mountain depressions (Stâna de Vale), slopes (Dumbrăviţa de Codru, Zece Hotare), terrace in a depression (Ştei) recorded minimum values in other directions, depending on the specific topoclimatic conditions: north-east with 2,2 m/s at Stâna de Vale and 2,4 m/s at Ştei, northwest with 2,0 m/s la Dumbrăviţa de Codru, southeast with 2,2 m/s at Zece Hotare, west and south-west with 1.9 m/s at Moneasa (Table 3).

Tab. 3. Annual average wind speed (m / s) on cardinal directions in the Crişul Negru hydrographic basin

Station	N	NE	E	SE	S	SV	V	NV
Vlădeasa	2.6	2.7	3.6	3.1	2.5	4.2	5.7	3.1
Stâna de Vale	2.3	2.6	2.8	2.7	2.7	2.6	2.3	2.2
Moneasa	2.9	2.5	2.7	2.5	2.1	1.9	1.9	2.4
Zece Hotare	3.3	3.0	2.5	2.2	3.6	4.1	3.6	3.0
Dumbrăviţa de Codru	2.4	2.2	2.4	2.9	3.5	3.3	2.6	2.0
Ştei	3.0	3.1	2.5	3.4	3.3	3.3	2.8	3.4
Holod	3.0	2.1	2.2	2.4	3.3	3.5	3.0	2.7
Ineu	2.9	2.4	2.1	2.8	3.3	3.0	2.7	2.6
Chişineu Criş	3.5	3.1	2.4	2.5	4.0	3.9	3.5	3.4
Salonta	2.9	2.7	2.1	2.2	3.5	3.4	3.3	2.8

Source: Data from the A.N.M. Archives

3.2.2. The monthly average wind speed on the cardinal directions. It has similar values with the average annual speed, being respectively the highest and lowest on the same directions as in the case of the annual analysis.

Thus, at the highest altitudes from the Crişul Negru hydrographic basin represented by the Vlădeasa meteorological station, the monthly average speed occurs in the winter months of December and January when the wind is blowing with 71 m/s in a westerly direction and the lowest monthly average speed occurs in the summer months of July, August and September when the wind is blowing only with 1.9 m/s from south (Table 4).

In addition, the other stations keep the same feature: Stâna de Vale has the highest monthly average during winter in December, January and February when the wind blows with 3.1 m/s from northeast and east, and the lowest monthly average speed on directions occurs during summer in August, when the wind blows from the north-eastern sector with 1.5 m/s. At Ştei there is a maximum speed during winter in December when the speed is of 4.5 m/s in the north-eastern sector, while the lowest average speed occurs in January, 1.8 m/s in a westerly direction (Table 4).

Tab. 4. The monthly and annual average speed of the wind (m/s) on the cardinal in the Crişul Negru hydrographic basin

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Station/direction	VLĂDEASA												
N	3.0	3.3	2.7	2.5	2.2	2.3	2.8	2.1	3.1	2.4	2.7	2.3	2.6
NE	3.1	3.7	2.9	2.9	2.5	1.9	2.4	2.4	2.5	2.4	2.6	2.4	2.7
E	4.7	5.0	4.2	4.0	3.1	2.7	2.7	2.7	2.8	3.0	3.8	4.1	3.6
SE	4.2	3.3	3.5	3.7	3.2	2.7	2.4	2.4	2.4	3.1	3.4	3.7	3.1
S	2.0	3.6	2.0	3.0	2.3	2.2	1.9	1.9	1.9	2.2	3.2	3.2	2.5
SV	4.8	5.3	4.4	4.4	5.6	3.8	3.1	2.8	3.6	3.9	4.1	4.8	4.2
V	7.1	6.3	6.6	6.0	5.3	4.8	4.5	4.2	5.2	5.4	6.0	7.1	5.7
NV	3.9	3.8	2.9	3.2	2.9	3.0	2.6	2.4	3.0	2.8	2.9	3.4	3.1
Station/direc	STÂNA DE VALE												
N	2.3	2.3	2.2	2.1	2.5	2.3	2.2	2.0	2.1	2.2	2.4	2.5	2.3
NE	3.1	2.1	2.3	3.1	2.5	2.3	2.4	1.8	2.9	3.0	3.0	3.1	2.6
E	2.7	3.1	2.4	2.9	2.8	2.6	2.8	2.8	2.5	3.1	2.9	2.7	2.8
SE	2.8	2.9	2.9	2.7	2.6	2.6	2.5	2.5	2.6	2.6	3.1	3.0	2.7
S	2.8	3.1	2.8	2.2	2.5	2.5	3.0	2.5	2.9	2.7	2.7	2.7	2.7
SV	3.0	2.5	2.5	2.7	3.1	2.6	2.2	2.3	2.6	2.5	2.8	2.7	2.6
V	2.3	2.3	2.4	2.6	2.2	2.2	2.1	2.2	2.2	2.3	2.1	2.5	2.3
NV	2.1	2.3	2.1	2.2	2.3	2.3	2.1	2.0	2.1	2.4	2.2	2.1	2.2
Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	AN
Station/direc	ŞTEI												
N	3.1	2.8	2.9	3.4	3.0	3.0	3.2	2.7	2.9	3.0	2.8	3.0	3.0
NE	2.4	2.5	2.6	2.9	3.4	3.4	3.0	2.9	2.9	2.5	3.6	4.5	3.1
E	2.2	2.8	2.7	2.7	3.3	2.6	2.2	2.2	2.5	2.4	2.1	2.6	2.5
SE	3.7	3.6	3.7	3.5	3.3	3.1	3.0	2.9	3.1	3.4	4.3	3.9	3.4
S	3.7	3.6	3.5	3.4	3.1	2.9	2.9	2.9	3.0	3.3	3.7	3.7	3.3
SV	3.4	3.2	3.9	3.9	3.3	2.9	2.9	3.0	3.5	3.1	3.6	2.9	3.3
V	1.8	2.9	2.8	3.2	3.3	2.6	2.9	2.8	2.8	2.6	2.9	2.5	2.8
NV	3.4	3.6	3.5	3.6	3.6	3.4	3.3	3.4	3.3	3.2	3.3	3.3	3.4

Source: Data from the A.N.M. Archives.

3.2.3. The average wind speed in any direction. Except the high peaks, the average annual speed calculated regardless of direction is reduced in Crişul Negru hydrographic basin (Table 5).

Tab. 5. The monthly and annual average wind speed in any direction

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Vlădeasa	9.5	9.1	8.6	7.9	6.7	6.4	6.5	5.7	6.6	7.0	9.4	9.7	7.8
Stâna de Vale	0.6	0.7	0.8	0.8	0.6	0.5	0.5	0.5	0.5	0.7	0.7	0.6	0.6
Ştei	1.9	2.0	2.0	2.0	1.8	1.7	1.6	1.5	1.7	1.9	2.1	1.9	1.8
Holod	1.8	2.3	2.7	2.7	2.4	2.2	2.0	2.0	1.9	2.0	2.0	1.9	2.2
Chişineu Criş	2.1	2.3	2.4	2.7	2.5	2.1	1.9	1.6	1.7	1.8	1.9	2.2	2.1

Source: Data from the A.N.M. Archives.

Thus, the largest annual wind speeds (7.8 m/s) occur on the highest peaks of the Crişul Negru hydrographic basin, represented by the meteorological station Vlădeasa where the friction with the land area is smaller. Instead, at Stâna de Vale, all because of the morphology of the field (located in the homonymous depression which is 2 km long, more than 2 km wide and well closed by peaks higher than 200-500 m) it was recorded the lowest annual average wind speed of 0.6 m/s, a fact also highlighted by Gaceu (2005), *** (2008). At lower altitudes the wind speed is greater than at Stâna de Vale because these stations are not so well sheltered from the general circulation of the atmosphere; they recorded values of 1.8 m/s at Ştei, 2.2 m/s at Holod, 2.1 m/s at Chişineu Criş etc. (Table 5).

3.3. Strong winds and wind storms

3.3.1. Frequency of days with strong wind and wind storms. According to the specialty literature (***, 1986, 1995) the strong wind is moving air that meets or exceeds the speed of 16 m/s and the wind storm is defined as a wind that begins and ends suddenly, lasts only a few minutes while the wind often changes direction, turning into gusts of wind that exceed 100 km/h (28 m/s).

In our analysis, as well as for other wind parameters, we processed data from all 10 stations located in the Crişul Negru hydrographic basin, but the content of this paper and the included tables present de values recorded by three stations that have a longer string of observations (Ştei, Stâna de Vale, Vlădeasa). We proceeded in this manner because, just like in the case of precipitations, the wind has a high variability in time and space and the values of the other stations that are calculated on a shorter period would have altered the results.

In the area of the Crişul Negru hydrographic basin the strong winds and the wind storms are rare, the only exceptions being met at high altitudes. Thus, the annual average frequency of days with strong wind varies between 0 days in the well sheltered depressions such as the Stâna de Vale depression, it reaches 1.8 days at Ştei in the Beiuş Depression which is wide open for the western circulation and exceeds 110 days at the highest altitude (Table 6, Fig. 5).

The maximum number of days per year with strong winds ranged from 1 day to Stîna de Vale, 14 days at Ştei and 160 days at Vlădeasa (Table 6, Fig. 5), due to the greater friction with land in the field area, to the topoclimate of the intermountain depressions which are well protected by the surrounding peaks and the reduced friction of the air with the earth's surface at high altitudes, a fact noted by Bâzâc, 1984, Gaceu, 2005, *** The Romanian climate, 2008 etc.

During the year, most days with strong winds occur throughout Vlădeasa (13.9 days) in January, at Ştei (0.3 days) in November, i.e. during the winter months when the thermal contrast between land and water is higher and the wind blows harder. The fewest days with strong winds occur in the months of late summer and early autumn, i.e. August-September when the anticyclone regime given by the Azoric anticyclone extension to our country dominates (Bâzâc, 1984; Fărcaş, 1983; Gaceu, 2005; *** The climate in Romania, 2008 etc.) and the average is of 5.2 days at Vlădeasa, 0.0 days at Ştei and Stâna de Vale (Table 6, Fig. 6).

Tab. 6. The monthly and annual average and maximum days with strong wind

Station/Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Ştei	m	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.2	0.3	0.2	1.8
	M	2	1	2	2	1	1	1	1	1	4	4	3	14
Stâna de Vale	m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	M	0	0	0	1	0	0	0	0	0	0	0	0	1
Vlădeasa	m	13.9	11.2	11.5	9.3	7.3	6.2	6.6	5.2	7.9	8.0	11.7	12.9	110.0
	M	26	22	24	17	17	17	18	16	16	23	26	23	160

Source: Data from the A.N.M. Archives.

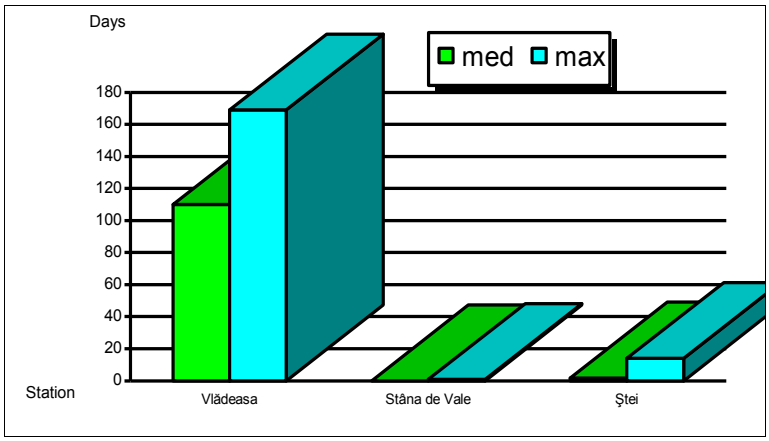

Fig. 5. The annual average and maximum days with strong wind (>16 m/s) in the Crişul Negru hydrographic basin.

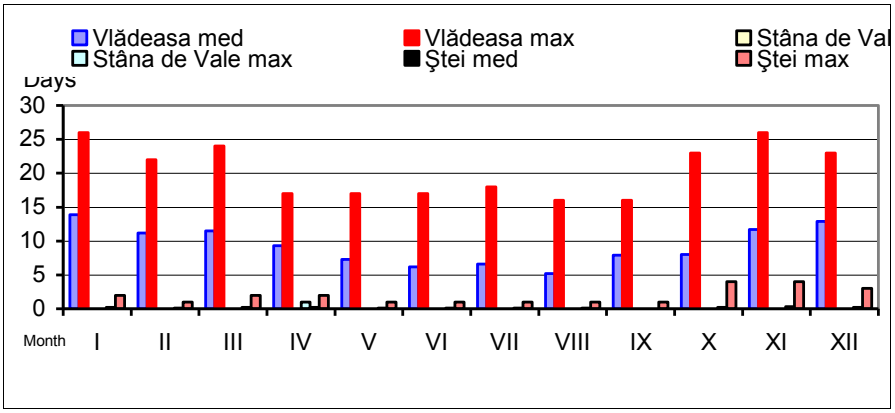

Fig. 6. The monthly average and maximum number of days with strong wind (>16 m/s) in the Crişul Negru hydrographic basin.

Analyzing the frequency of days with wind storms, we found that it is much more reduced than the frequency of the strong windy days. Therefore, the annual average of the days with wind storms reaches only 1.6 days at Vlădeasa, 0.4 days at Ştei and 0.3 days at Stâna de Vale, while the maximum annual number of days with wind storms totals 27 days at Vlădeasa, 4 days at Ştei, 3 days at Stâna de Vale (Table 7, Fig. 7).

Tab. 7. The annual and monthly average and maximum number of days with wind storms

Station/Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Ştei	m	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.4
	M	0	0	1	1	1	1	0	3	0	0	0	1	4
Stâna de Vale	m	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3
	M	0	0	0	0	0	1	2	0	0	0	0	0	3
Vlădeasa	m	0.1	0.1	0.4	0.1	0.2	0.1	0.3	0.3	0.0	0.0	0.0	0.0	1.6
	M	5	3	8	3	2	2	4	4	0	0	1	1	27

Source: Data from the A.N.M. Archives.

During the year, in the Crişul Negru hydrographic basin area, the average number of days with wind storms is low: 0.4 and 8 days at Vlădeasa, 0.2 and 2 days at Stâna de Vale, 0,2 and 3 days at Ştei, the phenomenon of winds storms occurring mainly in the summer months as a result of the increased thermal and dynamic convection that generates clouds with vertical development like Cumulus congestus and cumulonimbus, and also in the spring months, when the basin area is crossed by a succession of cold fronts, characterized by significant thermo-baric contrasts (Fărcaş, 1983; Bâzâc, 1984; Cristea, 2004; Gaceu, 2005; Moza, 2009; Şerban, 2010; ***, 2008 etc.).

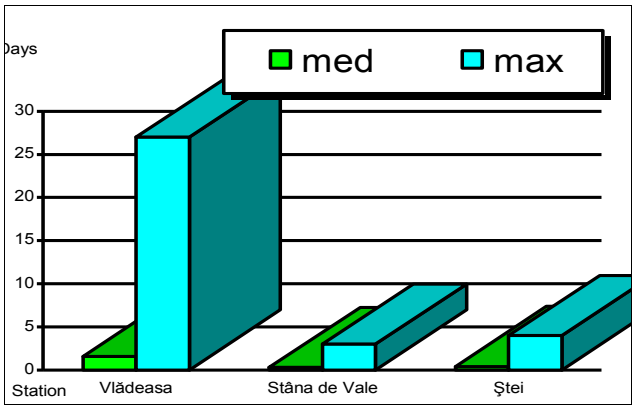

Fig.7. The annual and monthly average and maximum number of days with wind storms in the Crişul Negru hydrographic basin.

3.3.2. The absolute maximum speed and wind direction. The highest absolute wind speeds from the Crişul Negru hydrographic basin are recorded, as expected, on the highest peaks in January, in the western side: 62 m/s in 1976 at Vlădeasa. But with decreasing altitude and changes in topography, as in with the increasing

of the land surface and air friction process, the maximum absolute values of the wind speed is reduced to 20 m/s at Stâna de Vale (April 1983, in the south-eastern sector), 28 m/s at Ştei (June 1982, in the western sector), etc., the western direction found preponderantly at high altitudes changes (wind blows from the other cardinal points) and the maximum speed can be recorded during spring (due to the cold fronts) or during summer (due to the intensification of the thermodynamic convection)) (Fărcaş, 1983; Bâzâc, 1984; Cristea, 2004; Gaceu, 2005; ***, 2008 etc.) (Table 8, Fig. 8).

Tab. 8. The monthly absolute maximum speed (m/s), the direction from which the wind blows and the year of the recording at several meteorological stations from the Crişul Negru hydrographic basin

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Ştei	17, V, 76	16, V, 77	16, SSE, 92	14, NV, 82	14, SSV, 80	**28, V, 82**	13, N, 78	12, S, 77	12, NV, 74	17, SSE, 75	12, SSE, 84	14, SSE, 81	28, V, 82
Stâna de Vale	12, SSE, 86	10, E, 88	14, S, 83	**20, SE, 83**	10, SE, 84	9, VNV, 93	10, SE, 1996	8, ENE, 86	12, SE, 84	14, E, 81	14, V, 83	14, E, 81	20, SE, 83
Vlădeasa 1800	**62, V, 76**	60, V, 77	43, V, 79	>40, V, 97	45, SV, 78	52, V, 82	>40, V, 80	42, V, 77	>40, V, 95	42, V, 83	43, V, 77	50, V, 76	62, V, 76

Source: Data from the A.N.M. Archives.

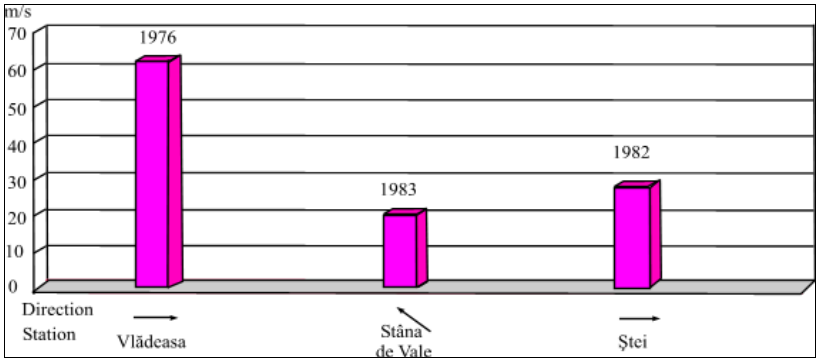

Fig. 8. The monthly absolute maximum speed (m/s), the direction from which the wind blows (arrows) and year of recording at several meteorological stations from the Crişul Negru hydrographic basin.

Conclusions

Analyzing the main parameters characterizing the wind from the Crişul Negru hydrographic basin we reached the following conclusions:

a) Topography influences the main features of the wind, in the sense that it may increase or decrease its speed and it may alter its direction etc. (Bâzâc, 1984; Gaceu, 2005; *** The Romanian climate, 2008 etc.).

b) The highest frequency of the wind, both monthly and annually, is recorded in the western sector, 40% on the highest peaks of Vlădeasa where the friction with the land surface is reduced, 7-10% in the sheltered valleys of Stâna de Vale, Moneasa where the friction with the land surface is higher and at at lower altitudes where the predominant frequency is found in the southern and south-western sides: 20% at Zece Hotare, 17% at Dumbrăviţa de Codru, 33% at Ştei, 11% at Holod or in the lowest northern areas of Chişineu Criş (13%) and Salonta (14%).

c) The calm winds have a normal frequency for this area (10-11% at heights, 30-40% for small and medium altitudes), except for the depressions where most of the cases are characterized by the lack of wind: 53% at Moneasa 75% at Stâna de Vale, the latter having the second frequency for calm winds in Romania after the station Titeşti (Bogdan, Dragotă, 1997 Gaceu, 2005; Vlaicu Gaceu, 2009).

d) Wind speed is within normal limits for the location and the topography of the Crişul Negru hydrographic basin, the annual average being between 7.8 m/s at the highest peaks of Vlădeasa and below 2 m/s at the other stations located in depressions or at lower altitudes. During the year the highest speeds occur at low and medium altitudes during spring and at high altitudes during winter, basically during the periods of atmospheric instability, while the lowest speeds occur in late summer and early autumn, when the serene and peaceful anticyclone, brought by the extension of the Azoric Anticyclone, dominates (Măhăra and co., 1977; Gaceu, 2005; *** The Romanian climate, 2008; Vlaicu, Gaceu 2009 etc.).

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EVALUATION OF HEALTH CONSEQUENCES OF AIR POLLUTION INDUCED BY BEAM ROLLING MILLS FACTORY (IRAN)

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Key words: indoor, out door, smoker, non-smoker, occupational fatigue, cardio-vascular disease.

Abstract. The increases in air pollution over the metropolitan cities are a threat to human health and environment. An attempt has been made to evaluate the health consequences of indoor air pollution induced by Beam Rolling Mills Factory at Ahwaz (Iran). A questionnaire was prepared to obtain information on health of 481 workers, out of which 200 each were selected from exposed and non-exposed category by stratified randomized method**.** Fisher exact test and chi-square test were used to calculate the values. The study concludes that more than 80% of the workers have high exposure risk to diseases. Analysis of the health impacts reveals that exposed workers are more prone to various diseases as compared to the non-exposed workers. It is also observed that exposure to air pollutants might be the causative factor for various diseases among the smokers but also non-smoking workers. The analysis also reveals that there is higher relative risk in occupational fatigue and cardio-vascular disease. Further, the study found that percentage of workers having various diseases is much higher in the indoor environment as compared to the outdoor environment

Introduction

The increasing levels of air pollution in the metropolitan cities are posing serious threat to human health and environment and warrant rigorous control and management. Hence, monitoring and assessment is the primary step in these programs. In fact, standards and regulations prescribed till now to protect human health and welfare have been based on ambient air pollution levels. However, recently, it is being realized that ambient air observations obtained from central

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monitoring stations do not accurately represent human exposures of "air people breathe" and hence corresponding risk to health. This is because of large spatial and temporal variations of air pollutants and because of diversity of human activities.

Several research studies highlighted that indoor air quality poses a serious threat to human health where people spend 80-90% of their time indoors in their residences, offices, shops etc (Simoni et al., 1998). There are also reports that of serious risks to health from exposure to PM in many cities of developed and developing countries (WHO report, 2005). The effects of inhaling PM have been studied on asthma, lung cancer, cardiovascular issues and premature deaths. The size of the particles is the main determinant in the respiratory problems (U.S. EPA, 2008).

Indoor air pollution is a major global public health problem requiring increasing efforts in research and policy making (Bruce et al., 2000). The concentration of several pollutants can be many times higher in indoor than outdoors (Book et al., 1991). Therefore, it is interesting to understand the quality of the indoor air we breathe in.

Several studies have investigated the effects of indoor air pollution on health of the infant children and elderly people (Jaakkola, 2000; Jaakkkola and Jaakkola, 2002). Numerous studies have reported links between air borne particles and a whole range of respiratory/cardiovascular symptoms, pulmonary function deficits and increased mortality (Abbey et al., 1995; Thurston et al., 1994; Wilson and Spengler, 1996). Some findings suggest that particle fractions significantly smaller than $PM_{2.5}$ may be of great importance for human health (Dreher et al., 1996; Peters et al., 1997; Tsai et al., 2000). Other studies (Lin et al., 2002; Zhang et al., 2002) suggest that coarse particles are more closely associated with asthma. Premature mortality is usually found in individual with pre-existing cardio respiratory disease (Shwartz and Neas, 2000; Goloberg et al., 2001).

Emissions from the industries also contribute to air pollution. Particularly, Iron and Steel plants represent major sources of atmospheric pollution by dioxins (Evaraet and Baeyens, 2002, Gilpen et al., 2003). Studies were also conducted on the people living around the incinerators exposed to dioxin in Wallonia (Belgium) (Sebastien, 2007). Chemical factories like welding fumes containing manganese and other heavy metals may result in adverse health effect on the neurological, respiratory and cardiovascular system (Bowler et al., 2006). Some studies also reveal that steel workers with exposure to polluted workplace had 14% increased risk of lung and stomach cancer (Zhaoyi et al., 1998) and cancer morbidity (Yeon-Soon et al., 2006). On similar lines, several studies were conducted to assess the effect of pollution generated by iron and steel factories

and risk to the health of workers as well as residence in the nearby areas (Chai et al., 2004; Hoshuyama et al., 2006; Amal et al., 2008; Bourgkard et al., 2008).

During recent years, the understanding of the mechanisms that control indoor air pollutions is of increasing interest among the scientific community as a result of growing concerns related to the effects on human health. More attention has been paid to occupational health impact at workplace particularly in mining, metal refining and metal working industry.

Iran's rapid economic growth is being built on a frame of steel. A soaring demand by sectors like infrastructure real estate and automobiles at home and abroad has put Iran steel industry on the world map. Iran rank 21st in 2008 in terms of world steel productions produced 10 million tones. However, there are very few studies related to the indoor air pollution of the industries, in general, and from Iron and steel industry, in particular; therefore, the present study for the first time attempts to analyze the indoor air quality in Beam Rolling Mills Factory, Ahwaz, Iran.

With these considerations in background, the present papers attempts to evaluate the health consequences of pollution induced by Beam Rolling Mills Factory. This paper discusses the impact on health arising from the pollutants from the Beam Rolling Mills Factory.

1. Materials and methods

A questionnaire was prepared to obtain information related to demographic characteristic, educational qualification, their habits and the problems related to the health. Beam Rolling Mills Factory has 481 workers, out of which 200 workers were selected from exposed category. In addition 200 workers were selected from non-exposed category by stratified randomized method. These questionnaires were given to 200 exposed and 200 non-exposed workers, thus a cohort study was conducted among workers.

They were then matched, based on various criteria such as age, work experience, and smoking habits. All the 400 workers selected were asked to fill up the questionnaires. Data of questionnaire were analysed by SPSS software. Categorical analysis (Fisher exact test) was performed to calculate the Odd Ratio and P values.

The Odd–Ratio is a widely accepted statistical method used to compare the frequency of exposure to risk factors in epidemiological studies. Calculating the Odd Ratio for a set of data which is fairly straight forward, 2X2 contingency table is first constructed. Then, computation of the Odd- Ratio is done,

Odds Ratio= (A/B)/(C/D) = (AXD)/(BXC).

If Odd Ratio is >1 and P < 0.05 only then Relative risk was computed. Relative Risk is the ratio of probability of the event occurring in the exposed group versus a non-exposed group (Sistrom et al., 2004).

RR=P exposed / P non-exposed.

Tab. 1: Relation between smoker/non-smokers with diseases

Risk	**Disease status**	
	Present	**Absent**
Smoking	*a*	*b*
Not smoking	*c*	*d*

RR =a/(a+b)/c/(c+d)

Relative Risk was computed by using the odd ratio for exposed smokers, and workers having exposed cardiovascular diseases, complaining of chest tightness, cough, difficulty of remembering, work experience, tension, occupational fatigue, occupational stress etc are reported in Table 2 (a-e).

2. Observations regarding the status of the workers

Demographic features in terms of age of exposed and non-exposed workers are reported in Table 2.

Table 2(a): Age distribution of exposed workers

Age (year)	N	%
30-39	47	23.5
40-49	128	64.5
50-59	25	12.5
Total	200	100

Tab. 2.(b): Work experience and educational qualification

Index	Exp.	Non-Exp.	Qualifications	Exp.	Non-Exp.
< 11	6 (3%)	18 (9%)	Under diploma	101(50.5%)	20 (10%)
12-17	71 (35%)	94 (47%)	Diploma	57(28%)	69(34%)
18 –23	100(50%)	69 (34%)	Pass Diploma	18(9%)	20(1%)
24- 29	19 (9%)	18 (9%)	B.Sc.	24(12%)	79(39%)
30- 35	4(%2)	1 (0.05)	M. Sc or higher	0(0%)	12(6%)
Total	200	200	Total	200	200

Tab. 2(c): Perception about cleanliness and lighting in work environment

Cleanliness	Exp.	Non-Exp.	Lighting	Exp.	Non- Exp.
R. clean	4(2%)	171(85%)	Very dark	13(6%)	0(%0)
Dirty	191(95%)	29(14%)	SD	141(70%)	38 (19%)
Very dirty	5 (2%)	0 (0%)	Suitable	46(23%)	162 (81%)
Total	200	200	Total	200	200

Note: R- Reasonably

Table 2(d): Perception about noise and seating in work environment

Noise	Exp.	Non- Exp.	Seating	Exp.	Non- Exp.
Very suitable	2 (1%)	15 (7%)	Comfortable	24 12%)	112 (56%)
RS	6 (3%)	116 (58%)	Uncomfortable	34 17%)	76 (38%)
SS	15 (7%)	48 (24%)	VC	31 15%)	7 (3%)
Not satisfactory	177(88%)	21(10%)	No exit	111(55%)	5 (2%)
Total	200	200	Total	200	200

Note: RS- Relatively suitable; SS-Somewhat satisfactory; VC- Very Uncomfortable

Table 2(e): Perception about satisfaction and climatic conditions

Satisfaction	Exp.	Non-Exp.	CC	Suitable	Unsuitable
VS	1 (0.05%)	13 (6%)	Hot season	13 6.30%)	187 (93.50%)
SS	59 (29%)	115 (57%)	Cold season	120 (60%)	80 (40%)
NTS	40(20%)	50 (25%)	Total	133	267
NAAS	100 (50%)	22 (11%)			
Total	200	200			

Note: CC-Climate conditions; VS-Very satisfactory; SS- Somewhat Satisfied; NTS- Not too satisfied; NAAS- Not at all satisfied.

It is clear from the above tables that: -

88 % of workers are reported in age-group 30 - 50 years.

More than 80 % of the workers have work experience between 12 and 23 years, indicating high exposure risk to the diseases.

50 % of exposed workers have education level only up to secondary school.

About 97 % of the exposed workers reported indoor environment as dirty, particularly the powder spillage resulting from iron (approximately 10 tons per day).

76 % of the exposed workers complain about insufficient light conditions and that 95 % suffer from noisy environments.

93 % workers endure from heat stress in their work place during hot season.

3. Analyses of the health impacts

The factual information does not clearly answer the following explicitly: -

Whether the exposed workers are more prone to different diseases as compared to non-exposed workers?

Whether smokers are more susceptible to different diseases? If not, what other factors might be responsible for causing various diseases?

Among the various diseases, which disease reflects higher relative risk?

To answer these questions, the data was subjected to chi-square test with the following null hypotheses: -

1). H_0 = There is no reason to assume that only exposed workers are prone to various diseases as compared to non-exposed workers.

H_1 = There is at least a reason to assume that only exposed workers are prone to various diseases as compared to non-exposed workers.

A table 3 is constructed with set of diseases arising out of the exposed and non exposed conditions using the Tables 2 (a-e).

Table 3: Diseases among exposed and non- exposed workers

Diseases	CV	CT	Cough	DIR	Tension	OF	UF	OS
EW	25	22	43	46	74	178	83	165
NEW	9	9	20	24	47	22	42	35

Note: CV-Cardio-vascular; CT- Chest Tightness; DIR-Difficulty in remembering OF-Occupational Fatigue; UF- Unusual Fatigue; OS- Occupational Stress; EW-Exposed worker; NEW-Non exposed workers.

Calculated Value (X^2) = 49. 6773

Degrees of Freedom = 7

Critical value at 0.05 level of significance = 14.067
Critical value at 0.01 level of significance = 18.475

As the calculated value is greater than the critical value at both the levels of 95% & 99%, the null hypothesis is rejected and hence the alternative hypothesis H_1 is accepted. Thus, there is at least some reason to assume that the exposed workers are more prone to various diseases as compared to the non-exposed workers.

In a similar manner in order to test whether only smoking is causative factor for the various diseases the following hypothesis is formulated:

2) H_0 = There is no reason to assume that only smokers are prone to various diseases as compared to non-smokers.

H_1 = There is every reason to assume that only smokers are prone to various diseases as compared to non-smokers.

For this each disease has been separately tabulated and discussed in the subsequent paragraphs.

4. Indoor environment

As the calculated value is less than the critical value for all the health related problems, the null hypothesis is accepted and the alternative hypothesis is rejected, except in the case of chest tightness. Thus, we can conclude that in indoor environment, there is no reason to assume that only smokers are prone to various diseases as compared to non-smokers (Table 4).

Table 4: Workers (smokers and non-smokers) and the diseases in Indoor

	CV		CT		Cough		DIR	
D	Yes	No	Yes	No	Yes	No	Yes	No
S	10	50	12	48	16	44	14	46
NS	15	125	10	130	27	113	31	109
Calculated Value ($\chi 2$)	1.361		7.092		1.356		0.034	
	Tension		OF		UF		OS	
D	Yes	No	Yes	No	Yes	No	Yes	No
S	27	33	53	7	29	31	50	10
NS	47	93	125	15	54	86	115	25
Calculated Value ($\chi 2$)	2.353		0.039		1.649		0.041	
Table value S and NS 0.05-3.841					Table Value S and NS 0.01-6.635			

Note: CV- Cardio- vascular; CT- Chest Tightness; DIR-Difficulty in remembering; OF-Occupational Fatigue; UF- Unusual Fatigue; OS-Occupational Stress; D-Disease; S-smoking; NS-Not smoking.

5. Outdoor environment

As the calculated value is greater than the critical value, the null hypothesis is rejected and the alternative hypothesis is accepted. Thus, we can conclude that, in outdoor environment, there is every reason to assume that only smokers are prone to various diseases as compared to non-smokers.

Conclusions

Comparing the result of both indoor as well as outdoor environment, it is clearly evident that apart from smoking, there might be another factor responsible for various diseases in indoor environment. Thus, exposure to air

pollutants might be the causative factor for various diseases among not only smoking workers but also non-smoking workers (Table 5).

Table 5: Workers (smokers and non-smokers) and the diseases in outdoor

	CV		CT		Cough		DIR	
D	Yes	No	Yes	No			Yes	No
S	9	30	9	30	20	19	24	15
NS	0	161	0	161	0	161	0	161
CV ($\chi 2$)	38.905		38.905		91.738		112.587	
	Tension		OF		UF		OS	
D	Yes	No	Yes	No	Yes	No	Yes	No
S	39	0	22	17	39	0	35	4
NS	8	153	0	161	3	158	0	161
CV ($\chi 2$)	157.711		102.046		182.254		175.136	
Table value S and NS 0.05-3.841					Table Value S and NS 0.01-6.635			

Note: CV- Cardio- vascular; CT- Chest Tightness; DIR-Difficulty in remembering; OF-Occupational Fatigue; UF- Unusual Fatigue; OS-Occupational Stress, D-Disease; S-smoking; NS-Not smoking.

Further analysis was done to investigate which particular disease has highest factor in context of the health-related problems of the workers. To achieve this, Relative Risk Technique was employed (Table 6).

Table 6: Relative risk in percentage for various diseases

Workers having various diseases in terms of percentage (%)								
Source	CV	CT	Cough	DIR	Tension	OF	UF	OS
EW	73.5	71	68	65	61	89	66	82.5
NEW	26.5	29	32	35	39	11	34	17.5
RR	2.78	2.44	2.15	1.92	1.57	3.90	1.98	2.09

Note: CV-Cardio-vascular; CT- Chest Tightness; DIR-Difficulty in remembering; OF-occupational Fatigue; UF- Unusual Fatigue; OS- Occupational Stress; RR-Relative risk.

It was found that maximum relative risk was observed in occupational fatigue (RR= 3.90) followed by cardiovascular diseases (RR= 2.78).

While monitoring the pollution levels, the present study has also noted the Wet Bulb Glob Temperature (WBGT) and the noise levels with the help of WBGT Set and Noise Meter respectively. NIOSH has recommended a standard of 25ºC WBGT and 85 dBA of noise level in heavy industries as criteria for healthy work environment. But here it was observed that the WBGT varied between 25ºC-27ºC and the noise levels were around 95 dBA, both far exceeding the NIOSH standards. This may be one of the reasons for higher relative risk in occupational fatigue and cardio-vascular disease.

It is also observed from the above study that percentage of workers having various diseases is much higher in the indoor environment as compared to the outdoor environment. Unacceptable work condition (unhygienic, noisy and dark work environment) may have increased risk of these problems. Unsafe measures like lack of use of respiratory masks may be another contributor.

In order to improve the workplace environment, following strategies are recommended:

Generating awareness for using safety equipment.

Frequently calibrating the machines at the workplace.

Implementing strict measures for mandatory medical check-up of all the workers at regular intervals.

Noise absorber to the area when high amplitude of noise is produced

To reduce (dust) RSPM /SPM a trapping machinery be installed

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ANALYSIS OF THE DYNAMICS OF THE FOREST SURFACES IN THE COUNTY OF IAŞI BETWEEN 1990 AND 2012

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Key words: forest surfaces, data quality check, Iaşi county, spatial and territorial autocorrelation effect

Abstract. The main dynamics that shaped the evolution of the forest surfaces between 1990 and 2012, in the county of Iaşi, are related to the legislative context and to the territorial reforms that affected the district limits. Analyzing these mechanisms in a geographical context shows that these trends are also related to the spatial frame. This study emphasizes that moderate negative coefficients of spatial and territorial autocorrelation can also describe these trends, suggesting that these evolutions are rather chaotic at local scale. This aspect makes us suspect that the loss of forest surfaces in each district is not only dependent on the economic, social and legislative context of the transition period, it is also subject to geographical factors. Analyzing these factors is the main intention of our study because they can provide us a better understanding of the extremely complicated frame of forest dynamics in the study area.

Introduction

Forest has always played an important role in human life, providing him with shelter, food (fruit, seeds and hunting resources), building material and tools. In Romania, the massive exploiting of forest is marked by the Treaty of Adrianople (1829) when the Romanian countries acquire their right to free navigation on the Danube and the Black Sea and the freedom of trade. Obtaining these privileges and population growth lead to increased farmland in the plains and plateaus areas by massive deforestation of broad-leaves forests, more accessible to coniferous forests in mountainous areas, their exploiting being more difficult and being conducting mainly to the top in the valleys. They then appear first problems caused by massive deforestation, a series of ordinances that aimed to protect forests (without much success though), followed by the reorganization of education and the emergence of

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forest science (forestry) and the establishment in Bucharest of the "Progress Forest" (1886) and the publication of "Forest magazine". The first half of the twentieth century is marked by a series of memorable political events (the two world wars, the end of the monarchy, the beginning of the communist regime), each taking its toll on the stability and sustainability of Romanian forests by changing the forms of ownership and the emergence of land reforms that actually had catastrophic effects, warning signs being held by a number of foresters such as Marin Drăcea, Emil Pop, Gheorghe Ionescu-Şişeşti, N. R. Danilescu, and more.

In the contemporary period, the forest acquires multiple functions, are increasingly often the main topic of scientific papers (Acad. C. Giurescu, Acad. V. Giurgiu, C. Chirită, etc.) but also the subject of numerous articles newspaper reports and political campaigns. Worldwide are set a number of international organizations and institutions aimed at the protection and sustainable development of forests ("is the kind of development that meets present needs without compromising future generations the chance to meet their own needs"-Commission World Environment and Development, 1987). In the Rio Conference (1992) appears ecological network Nature 2000, implemented in Romania between 2006-2008, currently about 18% of the country is considered to be protected areas.

The main trends in the research today more often link the forests to climate change. In a paper called Plan 3-0. Mobilizing to save civilization, L. Brown claims that the main issues that should concern today are the demographic pressure, the increase of CO2 gas, exhaustion of natural resources, global warming and that ” we cross verges that we can’t see and death-lines we don’t recognize ”. That is why it is necessary to take some global measures (Dieter H.F. Schoene and Pierre Y. Bernier, 2012; N. La Porta et al., 2008) to stop the long term effect of human society over the forest. Between 1990 and 2005 were recorded some of the most droughty and hottest years in the human history, the lasts research claim that until 2100 global temperature will rise in Europe with 3°C, even 4-5°C in the area of Black See (Lindner M., et al., 2010) and obviously affect the vitality of the forest, especially in the Southern part of Romania.

Another problem for the Romanian forest is the legislation (Giurescu, 1976; Giurgiu, 2000, 2010) and a poor collaboration between state institutions. The retrocession (a process that allows the return of forests nationalized under the communist regime back to the community owners or private ones, or to their descendants) that started at the end of ’90 become a real challenge for Romanian state who lost almost 70% of the forest surfaces (Lawrence, A., 2009) and is now facing a highly fragmented estate of private property (Nijnik., M., et al., 2009), with an average holding of 0.9 ha.

In this context, a study related to the evolution of forest surfaces at local and intermediate level is more than necessary, both for a better academic understanding

and for policy design support. This paper aims to identify the main trends that shaped the forest surfaces evolution between 1990 and 2012, based on data provided by reliable sources such as the NFA and TIFH, for the county of Iaşi. Using tools derived from the classical spatial analysis and cartographic depection of the dynamics, we identified the main chronological milestones in the evolution of the forests surfaces, at district scale. Subject to multiple political and legislative decisions (2 Forestry Codes published in the last 20 years) and territorial reforms (private forest districts), the dynamics of forest surfaces are sometimes hard to capture without a scrupulous data check methodology.

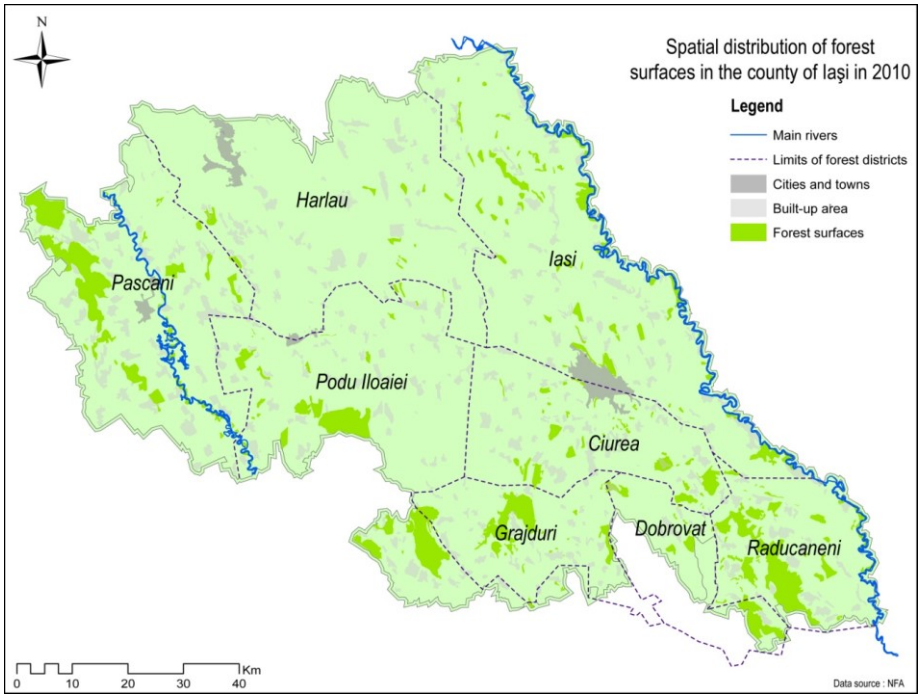

Fig. 1 Territorial distribution of forests in the County of Iaşi in 2010

Our main hypothesis states that the evolution's dynamics can be better understood when placed in a double geographical context - spatial and territorial. Our methodology is based on the construction of robust indicator of autocorrelation, which can be plotted in order to extract the trends. The cartographic analysis we propose serves as a secondary objective, explaining the dynamics at local scale (district), in various contexts (only 8 forest districts, a large amount of data, suspect values in the indicators or missing data).

1. Data and methods

1.1 Data Source

The main data we used in this paper is provided by the NFA (National Forest Administration) and covers the situation of forests in the county of Iași for the period 1990-2012, excepting the year of 1999 when the Forestry Authority of Iași was dissolved. A secondary data source is TIFH (Territorial Inspectorate for Forests and Hunting). The information collected from this source covers the period between 2006 and 2012. A major shift in the legislation regarding the reporting methodology explains why we needed a secondary data provider in our research, some of the indicators being used in this paper becoming available only in the TIFH statistics. The National Statistical Institute provides data only at NUTS3 and NUTS2 level, a geographical scale not appropriate for our study. However, the statistic information provided by this institution was useful in order to compare stock data summarized from the first two data sources. Due to uncertainty in the quality of data, the EEA Corine Land Cover layers were not included in our analysis.

The data provided by NFA was not on electronic support and needed adjustments for use in GIS and statistical analysis. The lack of metadata was another problem encountered during our work. As a matter of fact, despite the good intentions of the RNP, they still lack a territorial vision in the forestry administration, their statistical database being more appropriate for economic audit intentions. This problem of the metadata absence involved a severe quality data check for outlier detection. A total amount of 2420 indicators and variables populated the database we created for this research. They can be grouped on 5 major categories, declined by the property status - public vs. private. The indicator named Public property is divided in *forest in public property of state* and *forests in public property of the local administrative units*. The indicator labeled Private property is composed by *forests in private property of individuals and legal entities* and *forests in private property of local administrative units.* To these four categories we added the total surfaces. Territorially, our information covers 8 forest districts in the county of Iași. The geographical division in the spatial administration of forests is another topic of discussion. The forest districts of Grajduri, Răducăneni and Dobrovăț have surfaces in the administration that belongs to the county of Vaslui. The district of Podu Iloaiei used to manage 25 hectares of forest in the Neamț county, between 1990 and 2004. However, the data we integrated in the research is spatially referred to districts covering only the NUTS3 of Iași.

1.2 Data quality check

The analysis of data for quality check involved an error tracking by summarized indicators - total surfaces of forests, coniferous forests, broad -leaved

forests and other terrains. Generally, the error checking analysis revealed only minor mistakes, acceptable in our research. This type of errors (statistical outliers) is derived from misspecifications in the other terrains category. Less frequently, mistakes concerning the forest's total surface can be encountered. For example, in the case of the Răducăneni district a total amount of 160 hectares is missing from the reported surfaces (years of 1994-1996). These surfaces did not vanish, they were simply not taken into account as they were declared private property. This confused period of forests' restitution explains a large amount of the discrepancies within the data. The template of the statistical reporting of data was not constantly respected by the RNP, some of the data being excluded for incomprehensible reasons. When focusing on some particular years (e.g. the district of Podu Iloaiei in 1997) we observe significant differences between the total surface of other terrains and the sum of the indicators that compose this category (production, administration, constructions, afforestation etc.). What is inquisitive in this case is the fact that in the time series these mistakes are constantly revised and the errors are simply erased by adjusting other indicators. As a consequence of this data smoothing implemented by the NFA on the time-series, the total surfaces are always correct. As a first conclusion, taking into account the template of the reported information (variable in time), the issues observed for some particular years, the missing or not reported data, the quality data check was a necessary step in our research. In this moment, we estimate a rough ratio of 98 % reliable statistical information in our data collection.

1.3 Linking data to geometry

The base map we use in this paper is provided the RNP. At origin it was a. dwg file for AutoCAD use and spatial visualization. The layers were converted and imported in ArcGIS and over-layed. A join field was created in our database, in order to allow us mapping the indicators. The base map is composed by several layers: the 8 districts present in the county of Iaşi, the built-up areas (rural and urban), the major hydrographic network and the forest surfaces managed by the NFA in 2010. A .kmz file was created using Google Earth (c)tm and it contains the most recent image of the forest cover for the Iaşi county. It serves for spatial data quality check; our intention was to observe the differences or concordance between the NFA geometry (2010) and the satellite images.

1.4 Methods: statistical exploration and cartographic analysis

The methodology we mobilized in this research is based on a quantitative approach that follows prudent steps: data quality check, spatial analysis and time series analysis. The major problem we faced in our analysis is the reduced number of districts (only 8); this issue is compensated by the quantity of indicators obtained by data collection. As we intend to observe the trends in the forest surface evolution between 1990 and 2012, we will use two different methods -the

cartographic representation and analysis and the phase diagram instrument, the last one being extremely robust for trends identification. If the mapping process will emphasize the main dynamics of forest surfaces, at district level, the phase diagram will identify how these dynamics shift when changing the geographical scale. Basically, this phase diagram is a derived scatter-plot where the time is consubstantial to the data and the X and Y axis refer to the dynamics of two different spatial units.

2. Results and discussions

At the begining of the transition period (1990), the communist regime left a forestry fund of 6371 thousand hectares, most of it being located in the mountain and low-mountain area, more precisely in the North-West, Centre and North-East parts of Romania. That surface was the equivalent of 26.72 % of the country's surface. The North-East Region (six NUTS3 - Bacău, Botoşani, Iaşi, Neamţ, Suceava and Vaslui) was cumulating in that moment about 1186.6 thousands hectares int the forestry fund, from which 1168 thousand hectares of forests. The three mountain counties of Suceava, Neamţ and Bacău were leaders in the regional top, with nearly 82 % of the forest' surface. At regional scale the ratio between the species was almost equal - coniferous (581,5 thousand hectares) and broad-leaved species (586.5 thousand hectares).

At the same moment, the Forestry Authority of Iaşi was managing 8 forest districts (Paşcani, Dobrovăţ, Ciurea, Grajduri, Hârlău, Iaşi, Podu Iloaiei and Răducăneni); however, the spatial delineation of the forest surfaces was ignoring the county limits. Consequently, this authority was also managing forest surfaces in the neighbor counties of Vaslui (2927 ha, in 1990 with the districts of Dobrovăţ, Grajduri and Răducăneni) and Neamţ (25 ha managed by the district of Podu Iloaiei). The statistical reports are related to this territorial frame of forest management, our intention was to explore the early 90' database and to order the information independently to the counties limits.

In 1990 the National Forest Administration of Iaşi managed a total fund of 96310 hectares (94083 hectares of forests). Excepting 124 ha (from which 91 ha of forests) managed by the Minstry of Defense and some industrial compartiments in the districts of Paşcani, these surfaces were exclusively in the property of the state. At county level, analyzing the density of forests, the opposition between the northern districts and the central-southern ones is easy to observe. Moreover, this opposition remains stable in time (1990-1998) the dynamics of this indicator being extremely low. Comparing the districts, one can identify some interesting disparities in the forest repartition. Thus, almost half of the forestry fund is located in three districts: Paşcani (14057 ha), Ciurea (15427 ha) and Podu Iloaiei (17044 ha), while two other districts present similar values but significantly lower –

Dobrovăţ (9173 ha), Răducăneni (8813 ha). The last in this class is the district of Grajduri with a high-intermediate value of 11476 ha. All these 6 districts are in the category of spatial units with high densities of forest, on their territory.

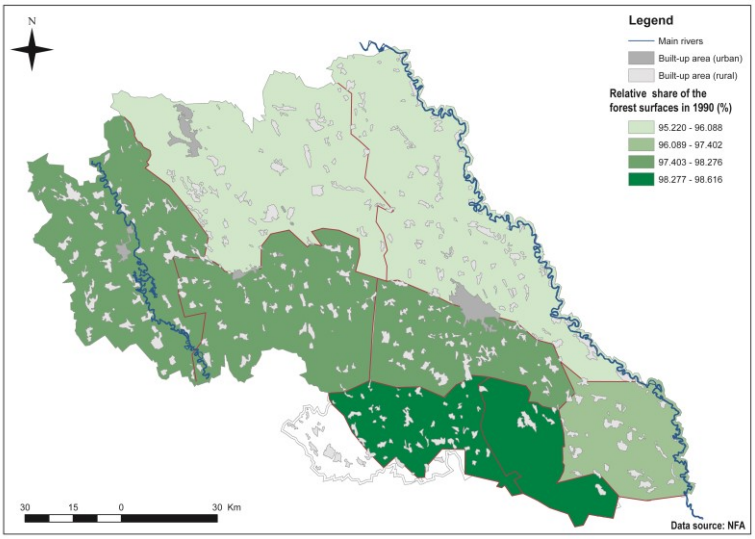

Fig. 2 Evolution of forest relative share at district level in 1990

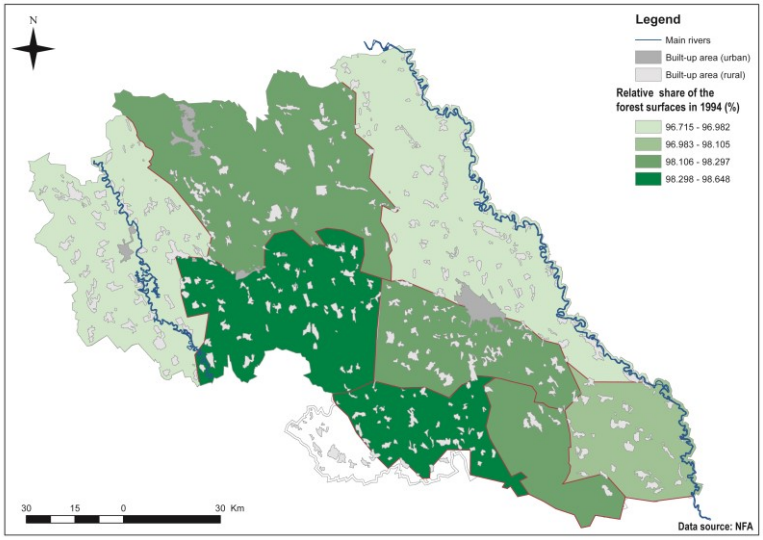

Fig. 3 Evolution of forest relative share at district level in 1994

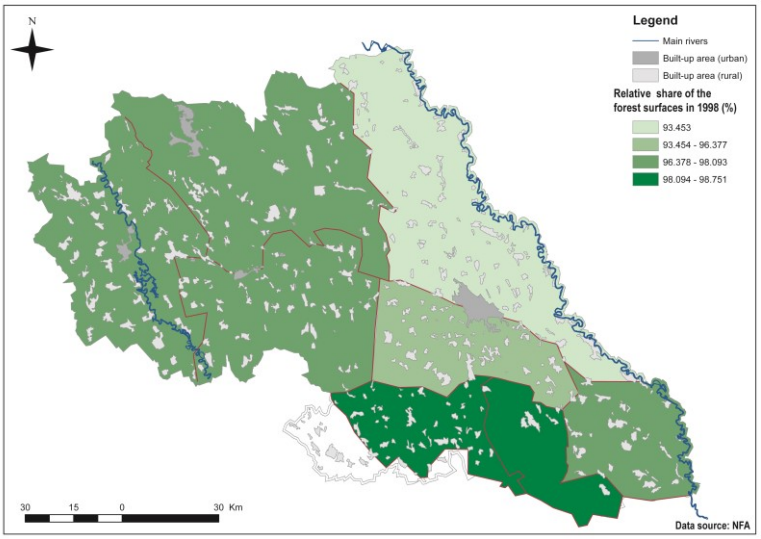

Fig. 4 Evolution of forest relative share at district level in 1998

The dynamics of the forest surfaces in the period of 1990-1998 is apparently stable, as the three maps (evolution of forest relative share in 1990, 1994 and 1998) illustrate. A point density map was used as tool to identify this overall general stability. The reduction of the surfaces covered by forest is almost unnoticeable in the northern part of the county (districts of Iași, Hîrlău and Pașcani), while in the southern area is more visible, especially in the districts of Dobrovăț and Răducăneni. This situation is not explained by the quality of data, active processes of deforestation being perceptible for this period of time.

In relative terms, some of the districts loosed almost 2 % of the forest managed by the RNP; it is the case of the district of Podu Iloaiei. Only one district registered an increase of forest surfaces, it is the case for Grajduri. The dynamics become more accelerated after the year 2000. For the next 12 years, the map shows a reduction of the forest surfaces that reaches almost 30% in the district of Podu Iloaiei. This negative trend is also visible for other spatial units, but less intensive. In the same time, the districts situated in the Valley of Prut river shows the most reduced deforestation trends (Iași and Răducăneni).

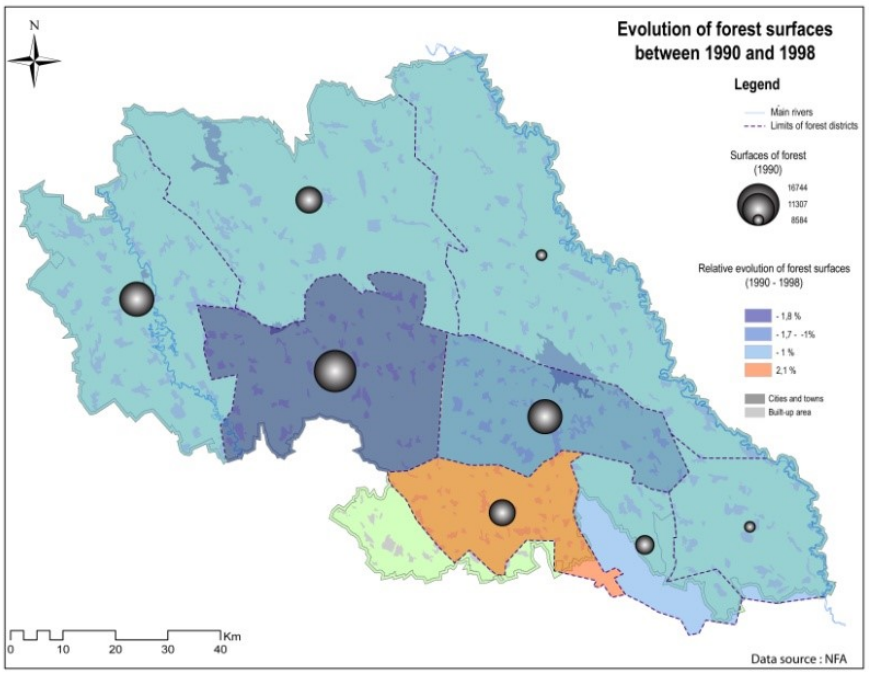

Fig. 5 Evolution of forest surfaces between 1990 and 1998

The trends we observe behave differently when analyzed in a spatial and territorial context. The method we propose will identify these trends using tools derived from the spatial analysis. Two particular instruments will be used in this approach: a chrono-variogram of spatial and territorial auto-correlation and the phase diagram using data for neighbor districts. In order to explore how the spatial and territorial context interfere with the dynamics of the forest surfaces, the relative evolutions of the indicators will be weighted with two binary matrices, one describing the neighborhood relations and one the territorial belonging.

Our main hypothesis states that there is a spatial and territorial effect in the evolution of forest surfaces, at district level. This effect can be measured by an indicator of spatial auto-correlation that was calculated for the period between 1990 and 2012. The first step in the implementation of this method is the construction of spatial weighted matrix of relations between the districts. We have made an option for a binary contiguity based matrix. With only eight districts to analyze, other methods proposed in the literature (inverse distance weight, k-nearest neighbors and fixed distance band) are not appropriated taking into account the small number of spatial units. The second step consisted in the preparation of a

dissimilarity matrix for two indicators - surfaces of forest at district level (absolute values) and their relative evolution between 1991 and 2012. The analysis was iterated for all the available years, excepting 1999, 2003, 2004 and 2005 (due to the missing of data) and the results synthesized in a correlogram that presents two

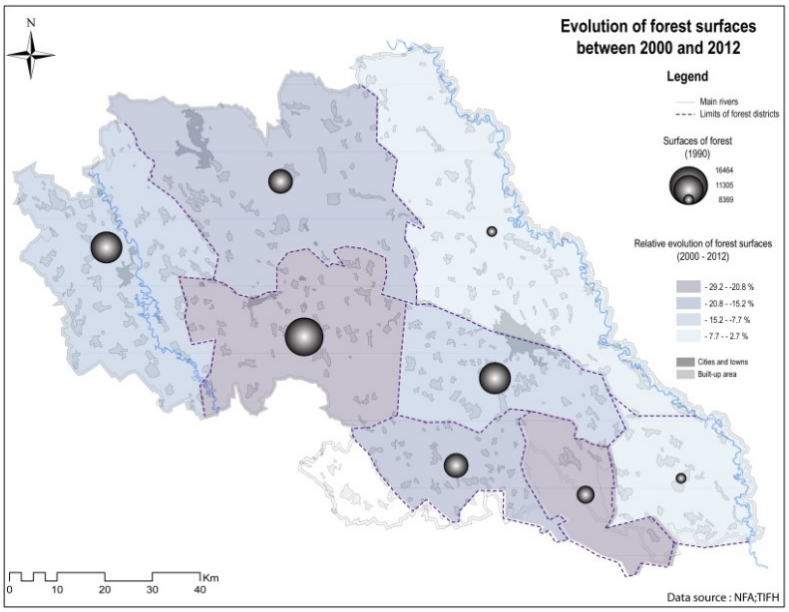

Fig. 6 Evolution of forest surfaces between 2000 and 2012

Tab. 1 Dissimilarity matrix for the relative evolution of forest (2012)

Dissim ij		CRT	1	2	3	4	5	6	7	8
		SU	PASCANI	DOBROVAT	CIUREA	GRAIDURI	HARLAU	IASI	PODU ILOAIE	RADUCANENI
CRT	SU	Y2012	91.93	79.10	83.58	81.56	84.24	95.47	69.61	96.17
1	PASCANI	91.93	0.000	12.832	8.345	10.368	7.692	3.545	22.315	4.239
2	DOBROVAT	79.10	12.832	0.000	4.487	2.464	5.140	16.377	9.483	17.072
3	CIUREA	83.58	8.345	4.487	0.000	2.023	0.653	11.890	13.970	12.584
4	GRAIDURI	81.56	10.368	2.464	2.023	0.000	2.676	13.913	11.947	14.607
5	HARLAU	84.24	7.692	5.140	0.653	2.676	0.000	11.237	14.623	11.931
6	IASI	95.47	3.545	16.377	11.890	13.913	11.237	0.000	25.860	0.695
7	PODU ILOAIE	69.61	22.315	9.483	13.970	11.947	14.623	25.860	0.000	26.554
8	RADUCANENI	96.17	4.239	17.072	12.584	14.607	11.931	0.695	26.554	0.000

distinct trends. The evolution of forest surfaces as absolute values has a constant trend of negative spatial auto-correlation (maximum: -0.31 and minimum: -0.14). This trend suggests that the evolutions observed are independent to the spatial

context, indicating the presence of a significant heterogeneity on the map. Locally, each district presents a trend of absolute evolution that differs from the neighbors.

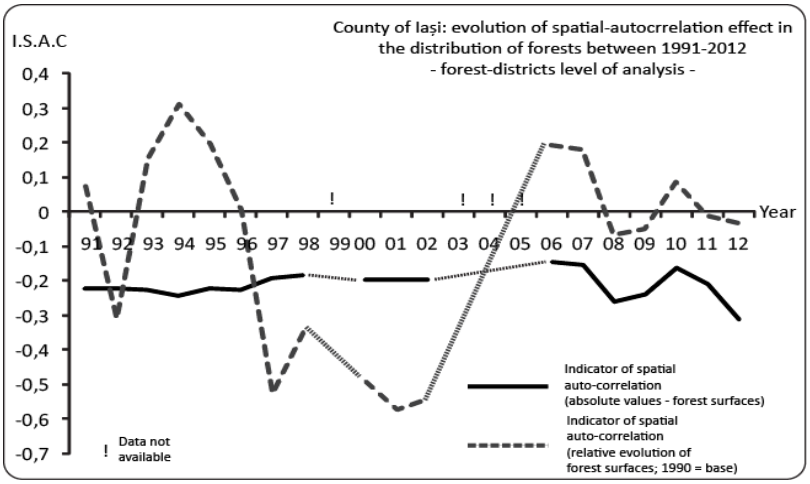

Fig. 7 Evolution of SAC effect between 1991 and 2012

Contrasting to the absolute evolution of the forest surfaces, the relative trends are marked by positive spatial auto-correlation. The graphic shows that the relative reduction or extension of forest surfaces was highly dependent on the spatial context for years like 1993, 1994, 1995, 2006 and 2007. The local trends become heterogeneous after 1996, if we analyze the values of the indicator, culminating with a strong negative coefficient in 2001(-0.57). The construction of the autocorrelation coefficient is based on the aggregated variance of the dissimilarities between districts, in a double context - neighborhood and non-contiguity.

$$I.S.A.C = 1 - \frac{\sum \frac{Dij}{n}; r = 1}{\sum \frac{Dij}{n}; r = 0}$$

I.S.A.C. =indicator of spatial autocorrelation
Dij = absolute dissimilarity between any two (i,j) districts, for the indicators we analyzed - value of the forest surfaces and relative evolution of forest surfaces.
n = number of spatial units
r = the value of the spatial relation between any two districts (1 if neighbors, else 0)

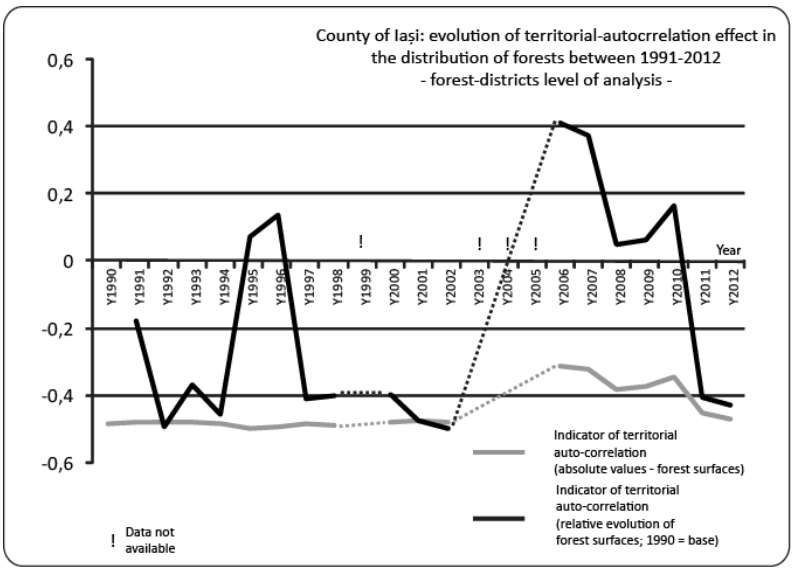

Fig.8 Evolution of TAC effect between 1991 and 2012

The value of the I.S.A.C could be interpreted similarly to the Pearson' coefficient of statistical correlation. If the value is closed to 1, we assist to positive spatial autocorrelation. When the value is closed to -1, one will deal with negative spatial correlation. When I.S.A.C. is closed to 0, we cannot detect the role played by space in the distribution of an indicator.

The same method of analysis was applied choosing a different context for the weighted values of the dissimilarities between forest districts, the territorial belonging. The eight districts were divided in two regions - the South Region (Răducăneni, Dobrovăț, Ciurea and Grajduri) and the North Region (Pașcani, Hârlău, Podu Iloaiei and Iași) and a new matrix was built (a binary table containing values of 0 and 1). Analyzing the maps, we suspected that this effect of territorial belonging could also explain the trends of evolution of the forest surfaces, either in absolute or relative terms.

After the iteration of the method we have obtained a graph that depicts the evolution of the coefficient of territorial autocorrelation between 1991 and 2012. The coefficient presents a strong and stable effect of negative territorial autocorrelation for the evolution of forest surfaces (absolute values). This should be interpreted as regional heterogeneity - any pair of districts belonging to the South or North region shows divergent trends of evolution. Contrary, in the case of the relative indicator, we observe a cyclical trend with two picks of positive

territorial autocorrelation (1996 and 2006). In this case, belonging to one region (South or North of the county) will partially explain the relative trends of evolution for the forest surfaces.

The synthesis of the analysis allowed us to identify some atypical years in the evolution of the forest surfaces, for the county of Iași, at district level. If the role played by the spatial and territorial context is stable and predictable, for the case of the absolute values, shifts will occur in the trends when analyzing the relative evolutions. Two years are particularly interesting - 1997 and 2006. For both years, the values of the SAC and TAC coefficients shift the sign, meaning that the influence played by the geographical contexts (spatial and territorial belonging) was reversed. Without systematically investigating the trends using the method we proposed, detecting these years would have been difficult, needing map analysis for 18 years of forest evolution.

Tab. 2 Outlier values of SAC and TAC in chronological context

	SAC_VAL_ABS	SAC_VAL_REL	TAC_VAL_ABS	TAC_VAL_REL
Y1990	-0.224		-0.486	
Y1991	-0.223	0.074	-0.484	-0.179
Y1992	-0.220	**-0.311**	-0.483	-0.499
Y1993	-0.225	0.153	-0.483	-0.371
Y1994	-0.243	0.310	-0.489	-0.458
Y1995	-0.222	0.195	-0.501	**0.070**
Y1996	-0.225	0.004	-0.496	0.135
Y1997	-0.191	**-0.528**	-0.488	**-0.415**
Y1998	-0.184	-0.349	-0.492	-0.402
Y2000	-0.196	-0.496	-0.482	-0.397
Y2001	-0.196	-0.576	-0.480	-0.479
Y2002	-0.196	-0.546	-0.481	-0.501
Y2006	-0.145	**0.192**	-0.313	**0.409**
Y2007	-0.153	0.177	-0.321	0.372
Y2008	-0.258	-0.071	-0.385	0.049
Y2009	-0.240	-0.052	-0.377	0.061
Y2010	-0.162	0.086	-0.347	0.161
Y2011	-0.207	-0.012	-0.452	**-0.408**
Y2012	-0.310	-0.036	-0.474	-0.434

Conclusions

In the almost chaotic context of the forest dynamics that affects the county of Iaşi, between 1990 and 2012, one can observe that these surfaces are decaying according to a geographical pattern that can be measured using the spatial and territorial autocorrelation coefficients. This decline is marked by heterogeneity, both at local and zonal scale (North vs. South of the county). The explanation of this heterogeneity should be linked to the legislative retrocession of forest surfaces, a legislative mechanism with different rhythms at district and LAU2 (local administrative unit - UAT) level. In this logic, the most affected districts are Paşcani, Grajduri and Podu Iloaiei. The chronological evolutions of the coefficients we propose indicate that there are some key years (1992, 1997 and 2006) that deserve a special focus in the analysis of the forest trends. If in 1992 the retrocession process just began to show its effects, in 1997 the legislative frame is changed by a new forestry code. In 2006 we assist to a massive change in the providing of official data related to the forest surfaces. The data from TIFH allows us to perform a more detailed analysis of the 2006-2012 period, introducing new actors involved in the management of the private surfaces. In the context of our study, the main conclusion states that despite the negative trends of evolution are not dramatic and that the geographical research should focus more on the administrative and legislative frame that explains how these trends function.

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ATMOSPHERIC DISPERSION OF PM10 IN AN URBAN AREA

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Keywords: PM10, atmospheric pollution, long-term trends.

Abstract. One way of monitoring the atmospheric pollution is to estimate anthropogenic emissions. This paper presents a study of PM10 emissions in a city SE of Romania (Braila) for the period 2009-2012. PM10 emissions decrease from 304.75 t in 2009 to 78.01 t in 2012. Using data from the Environmental Protection Agency Braila and the METI-LIS dispersion model, four maps were produced in order to estimate the spatial distribution of PM10 emission in each year. Results of dispersion models show that the air quality can change abruptly between points at few meters away. Expectedly, PM10 emissions increase towards the centre of the city centre, are generally higher in the vicinity of busy streets and roads.

Introduction

Air pollution distribution is important for estimating human exposure and environment, but usually sources of contamination are frequently difficult to monitor (Bravo et al., 2012) According to SNAP groups, the three significant contributors to urban air pollution are combustion in energy and transformation industries, waste treatment and disposal and road transport. Modelling urban air pollution is a very complex process since the dispersion is influenced by weather conditions, topographical features and urban structural particularities (Wang et al., 2008; Misra et. al., 2013). Dispersion models provide a tool which, in most cases, is based on the relationship between air quality and meteorological data. Results of several available dispersion models have demonstrated that the horizontal dispersion exceeds the vertical dispersion, but both depend on plume properties and the urban features (Saiers et al., 2003; Huang et al., 2008). Spatial dispersion techniques allow locating the source of pollutants and monitor those areas to reduce the negative effects and to conserve the quality of air (Song et al., 2008). By monitoring the relationships between pollutant emissions and the effects of smog,

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dust, and other harmful airborne pollutants on plant and human life, dispersion soft becomes an important tool can use to ensure that no further pollution occurs. (Zhang et al., 2012a).

Particulate Matter 10 (PM10) are particles with diameters less than or equal to 10 microns and is the general term used for solid particles and liquid droplets in the atmosphere. Generally, particulate matters contain a variety of chemicals usually associated with a number of components, including acids (such as nitrates and sulphates), organic chemicals, metals, dust particles, herbicides but also nutrients such as phosphorus for example (Masitah et al., 2007; Noe et al., 2007). PM10 is a major air pollutant in urban areas, mainly in developing countries, where EU limits for PM10 concentration in ambient air is frequently exceeded (EEA, 2012). PM 10 may result from several of natural and anthropogenic sources, including vehicle exhaust emissions, industrial emission sources, transport, agriculture, and smoke from forest fires. (Saleh et al., 2014). Besides effects on human health and biosphere, particle concentration is important also because of their influence on cloud formation and properties and on radiation budget of the earth-atmosphere system, which in turn may cause changes in the atmospheric circulation, surface temperature and precipitation (Leili et al., 2008).

Maximum accepted values for PM10 in the European Union were implemented on 1 January 2008, based on Directive 2008/50/EC. Maximum values of the annual mean are 40 $\mu g/m^3$while the short-term maximum value is that the 24-hour average of 50 $\mu g/m^3$ is not exceeded more than 35 times a year. Since many EU countries had difficulties in maintaining the above limitations for PM10, regulations have changed, since PM from natural sources increased (Brunekreef and Maynard, 2008).

In this study we show results of modelling the PM10 dispersion in an urban area taking into account the relationship between air pollutants (particulates matters – PM 10 and meteorological factors (temperature, wind speed, wind direction and atmospheric stability).

1.Data and method

The PM10 dataset for 2009 – 2012 comes from the Local Environmental ProtectionAgency. Inventories include estimates of all known atmospheric emissions. Emission estimates are collected into databases which usually contain data on the locations of the sources of emissions, emission measurements, emission factors, capacity, production or activity rates in the various source sectors (energy,industrial processes and product use, agriculture, waste, other), operating conditions, methods of measurement or estimation, etc (EEA, 2013). The European Monitoring and Evaluation Programme (EMEP/EEA Air Pollution Emission Inventory Guidebook) is a reference document systematically organized 11 SNAP

(Select Nomenclature for Air Pollution) codes in accordance with to the classification of sources of atmospheric pollutants. Data on emissions per SNAP source sector are collected by the local agency and stored into the national database, which are analysed in order to take the best decision for future strategy to improve the air quality.

Emissions can be calculated using the following relationship:

$$E_{i,j} = A_{i,j} \times FS_{i,j}, \quad (1)$$

where E is the emission time series, A is the activity rate time series, $FS_{i,j}$is the sectoral emission factor time series, i is the sector and j the pollutant.

The dispersion of PM10 was simulated using the METI–LIS software (Kouchi et al., 2004), a program developed originally by the Japan Ministry of Economy, Trade and Industry (METI, 2006). The METI-LIS, model ver. 2.03, is a Gaussian dispersion model and calculates concentrations in steps of one hour or less. Meteorological data and volume of emitted pollutant are essential input items for dispersion models. Wind direction, wind speed and atmospheric stability have a major contribution on dispersion (Kouchi et al., 2004). METI-LIS uses a dispersion equation for point sources the steady-state Gaussian plume. The origin of the calculation's coordinate system is placed at the ground surface at the base of the stack. The x axis is positive in the downwind direction, the y axis is crosswind (normal) to the x axis, and the z axis extends vertically. The user-defined calculation points are converted to each source's coordinate system for concentration calculation at each time period. The concentrations calculated for each source at each calculation point are summed to obtain the total concentration produced by the combined source emissions for that time period.

$$C_{(x,y,z)} = \frac{QV}{2\pi u_S \sigma_y \sigma_z} \exp[-0.5(\frac{y}{\sigma_y})^2] \quad (2)$$

C: Concentration in the x, y, z directions (m^3/m^3: ppb, ppm, or other units)
Q: Pollutant emission rate $(m^3{}_N/s)^2$
V: Vertical term
u_s: Mean wind speed at release height (m/s)
σ_y,σ_z: Dispersion parameters in the lateral and vertical directions (m)

2. Results and discussion

Table 1 presents the PM10 yearly average data per SNAP group. Data are collected by the local agency and stored into the national database,depending on each emission source by sector.

Table 1PM10 local emissions inventory, 2009 – 2012, according to SNAP Group [tonnes]

Group	SNAP groups	2009	2010	2011	2012
Group 1	Combustion in energy and transformation industries	42.10	12.91	15.33	5.86
Group 2	Non-industrial combustion plants	2.31	2.66	41.96	2.93
Group 3	Combustion in manufacturing industry	0.17	0.56	5.51	0.08
Group 4	Production processes	0.01	0.05	0.05	0.03
Group 5	Extraction & distribution of fossil fuels and geothermal energy	0.00	0.00	0.00	0.00
Group 6	Solvent and other product use	0.00	0.00	0.00	0.00
Group 7	Road transport	254.33	111.58	71.09	62.17
Group 8	Other mobile sources and machinery	0.53	1.43	0.90	1.24
Group 9	Waste treatment and disposal	5.30	5.57	5.33	5.71
Group 10	Agriculture	0.00	0.00	0.00	0.00
Group 11	Other sources and sinks	0.00	0.00	0.00	0.00

According to SNAP groups the most significant contributors to urban air pollution, in the studied area, are road transport, combustion in energy and transformation industries, waste treatment and disposal and non-industrial combustion plants.

Although agricultural activities are important anthropogenic sources in this area, PM10 pollution is zero, according to questionnaires completed by operators. Zero PM10 can be seen also in relation to Group 5, Extraction and distribution of fossil fuels and geothermal energy, which may be true because these activities are very limited. The most significant PM10 pollution originates from road transportation.

Fig. 1 shows the PM10 yearly contribution from each SNAP source, from 2009 to 2012. The PM10 emissions were calculated on the basis of declarations supplied by operators inventoried.

The main sources of PM10 in this area, according to SNAP classification is Group 1, Combustion in energy and transformation industries, 76.20 t and Group 2, Non-industrial combustion plants, contribute with 49.86 t, to total PM10 emission,

during the analyzed period. The PM 10 quantity recorded by Group 9, Waste treatment and disposal, was only 21.91 t.

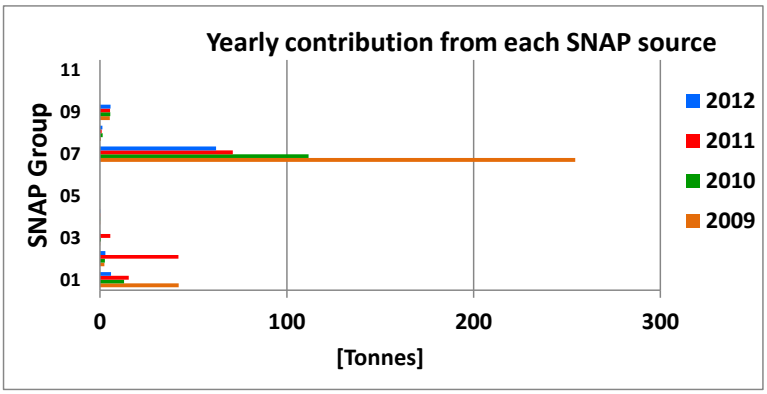

Fig. 1: Yearly contribution from each SNAP source, for 2009 -2012

Fig. 2 shows the PM10 emission evolution in Braila, during theperiod 2009 – 2012. According to local inventory the main contribution to urban air quality has the SNAP Group 7, Road transport, generated 499.17 t of PM10. Although the period is very short, a descending trend is observed, from 254.33 t in 2009 to 62.17 t in 2012. An important decrease is observed in 2010, when the amount of PM10 was 111.58 t, basically below less than 50% of the PM10 during the previous year.

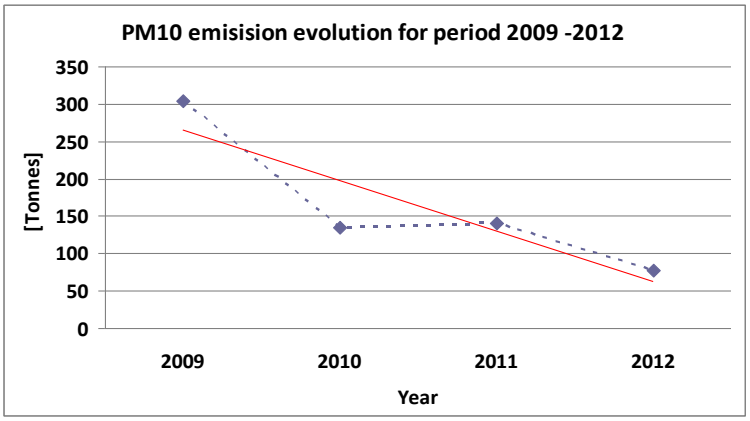

Fig. 2: PM10 emission evolution for period 2009 -2012

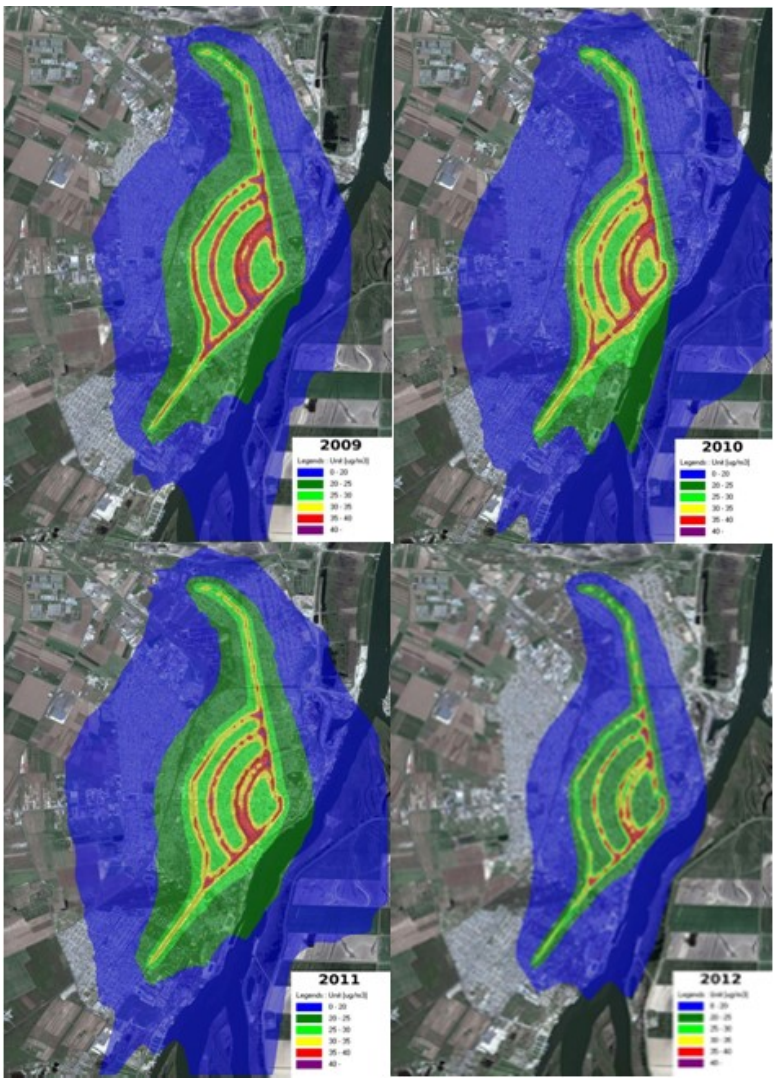

Fig. 3: Dispersion of PM10 for 2009-2012. PM10 concentrations between 0 and 20 µg/m^3 are shown in blue colour, 20-25 in dark green from 20 to 25µg/m^3, in light green 25-30 µg/m^3, in yellow 30-35 µg/m^3, in red 35-40 µg/m^3 and violet values over 40µg/m^3. Note that the intense green/blue to the SE of the map is due to superposition with the dark colours used in the map

The largest PM10 pollution, i.e. 304.75 t is seen in 2009 (the first year of the analysis), while in 2012 the PM 10 pollution was only 78.01 t. The decreasing

trend of PM10 observed in Braila city can be due to the industrial and economic decline but may be also a consequence of increasing number of car engines equipped with particle filter.

Four maps were created to obtain spatial distribution of annual averages of PM10 emission in Braila. Various scale patterns provides differential influence on air quality dispersion visualization and determine various accuracy of air quality monitoring. Smaller grids determine a more accurate model for typical area while for larger grids it calculates the mean for total grids.

METI-LIS model estimates a distribution of an emission in a relatively large area, such as Braila with a 50 × 50 m square spatial grid.METI-LIS was used to produce air pollution dispersion maps for each year, which are shown in fig. 3.

The highest PM10 concentration is seen along the main streets and in their close vicinity, obviously in connection with the traffic. The largest polluted zones were in the vicinity of busy streets and roads.

In accord with the emission inventory, the PM10 loading gradually decreases. High PM10 concentration is observed along all major roads in 2009, with some intermittency towards the periphery of the city. These intermittencies are also observed in 2010, 2011 and 2012 and appear, gradually, in the city centre. They are better observed when the PM10 concentration is low, as for instance in 2012. One possibility is that these are associated with meteorological factors, i.e. the wind. On the other hand, a careful look to the maps reveals that spots of PM10 appear mostly near cross-roads and, probably, near traffic lights.

The decrease of PM10 concentration in 2012 can also be observed as an important reduction of the polluted area, which is large, for instance in 2010 and 2011, but small in 2012. This is an effect of meteorological conditions, besides the reduced number of anthropogenic sources. Most likely, a SW wind carries PM10 loading to the south of the city in 2009-2011. An important reduction of PM10 concentration is observed especially at the outskirts of the city, to the West. Streets which were heavily polluted in 2009 tend to be less and less affected by traffic.

Conclusions

PM10 measurements and annual averages of meteorological parameters were used to map the PM10concentration in an urban area SE of Romania, namely in Braila, using the METI-LIS model, for a period of four years, 2009-2012. Expectedly, METI-LIS maps show that the highest PM10 concentration, thus the most polluted area, relates to point sources associated with traffic.

An important decrease of annual averages of PM10 concentration is observed from 2009 to 2012. PM10 spots still remain and are associated with traffic lights or cross roads. The surface distribution of PM10 is also affected, most likely, by

meteorological factors but also by reduction of point sources. Measurements support the general decreasing trend shown by calculated emissions at annual level.

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INFORMAL COLLECTION OF HOUSEHOLD SOLID WASTE IN THREE TOWNS OF ANAMBRA STATE, NIGERIA

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Key words: street collection containers, cart pushers, long distance

Abstract. Management of urban solid waste implies the collection, transfer, treatment recycle, reuse and disposal of such waste. Collection of urban household solid waste traditionally rests with government agencies designated with such responsibility. Solid waste collection begins from storage at the household level to the final treatment or disposal point and represents the most important aspect of urban solid waste management. Little has however been written on urban household solid waste collection in Nigeria. Using empirical data from three urban areas of Anambra State, Nigeria, the paper examines the place of informal private solid waste collectors in household solid waste collection. The ANOVA technique is used to test the null hypothesis that the sample means of the distance to designated community/street solid waste collection containers in the residential neighbourhoods of the three towns are equal. We conclude on household patronage of informal private solid waste collectors as against government provided community/street collection containers in the areas studied.

Introduction

A common and disturbing sight in the urban residential neighbourhoods in Nigeria are the heaps of uncollected household solid waste at strategic locations. Where the municipal or local authorities have community waste collection receptacles in these neighbourhoods, these are often filled up with household solid waste and spill over to the ground and into the nearby gutters. These receptacles and containers full of household solid waste are left uncollected for days and

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sometimes weeks and subsequently become feeding grounds for dogs as well as breeding grounds for rodents and other disease vectors. They also serve as areas for waste scavengers and picker looking for items form the waste dump which could be reused or sold for money.

According to (Walling et al., 2004), in Nigeria, there are insufficient public bins as the amount of trash that accumulates in a matter of hours appear to be more than waste collectors could collect in a day. In addition, a large percentage of the solid waste fails to to get to the urban public dump site. When refuse accumulates, households and businesses pile it in the median of major roads and burn it (Walling et al., 2004).

While waste exits in any of the following three forms, solid, liquid, gaseous or any of the intermingled form, (Cointreau, 1982; & Sha'ato et al., 2007) have noted that solid waste (garbage) specifically exists in either solid or semi-solid state. Therefore, solid waste refers to leaves, food remnants, builders' rubble, biomedical debris, household hardware, plastic materials, paper/cartons, textiles, bones, ash/dust/stones, dead animals, human and animal excreta, bottles/glass, leather and such materials as are thrown away as useless.

The management of urban solid waste is one of the most challenges environmental problems confronting Nigeria and other developing countries, where services are often poor especially in low income areas. Municipal solid waste management thus refers to the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas (Coffey and Coad, 2010). Collection of solid waste implies initial storage of waste in the household, business premises or shop, loading and unloading and transfer of the waste as well as all stages of the transportation of the waste to its final disposal or treatment point. While the common buzz words in the media and discussions about the management of urban solid waste are 'recycling' and 'reuse' it should however be noted that the collection and transportation of solid waste represent the most important aspects of municipal solid waste management, for they make the biggest demands on municipal finances and have one of the biggest impact on urban living in terms of public health and the appearance of cities and towns.

In terms of responsibility for collection, this has traditionally been given to the municipal authority, local government or specialised government agency tasked with the function of collection of household solid waste. A common and frequent deficiency however, is the failure of governments to provide sufficient financial resources to necessary to achieve an acceptable level of services for the urban areas of Nigeria and most developing countries. A further unfortunate situation in these countries is that the meagre financial resources are used to acquire inadequate and often inappropriate solid waste collection equipment or to maintain an insufficient and obsolete fleet (Coffey and Coad, 2010; Coad, 2011). The failure to provide

minimum levels of service by the authority tasked with the responsibility for collecting urban household solid waste in Nigeria may explain the rise in the growth in number and patronage of informal private waste collectors by households in the cities and towns across the country. Much has been written on urban solid waste management in Nigeria (see Babayemi and Dauda, 2009; Babalola et al., 2010; Ezigbo, 2012 and Ayuba et. al., 2013). These authors emphasise the need for an effective municipal solid waste management in the urban areas of Nigeria generally and highlight the different aspect of municipal solid waste management. However little has been written on household solid waste collection and even less so on the role of informal waste collectors.

Adebola (2006) observed that the inability of government owned agencies to effectively handle the upsurge in the quantity of municipal solid waste generated must have created a 'vacuum' in the collection, transportation, recovery, recycling and disposal of solid waste in Lagos, a vacuum, which was filled by both the formal and informal private waste collectors.

Olaruntade et. al., (2013) in their work, listed the quantity of municipal solid waste generated in Akure over an eleven year period, between 2000 and 2010, inclusive, noting that the increase over these years was attributed to the increased efforts by government to sanitise the city. Anierobi and Efobi (2013) in their study of Awka and Onitsha in Anambra State, note the role of the informal sector operators in sorting, re-useable and recycling materials from heaps of garbage in dumpsites and converting these wastes to something more useful at a high risk to their health. While these research efforts provide major insights into the study of urban solid waste collection in Nigeria, they however concentrate on the municipal wide level. They fail for example to look at the specific level of residential solid waste. Treatment at this level is very important since the biggest generators of municipal solid waste are the households. In addition, the above studies fail to provide information on the quantity of total household solid waste collected by government waste collection agencies and that which informal collectors cart away or other ways household choose to remove generated solid waste. It is equally necessary to determine specific failings of the public solid waste collection agencies, which households observe and which thus encourage the patronage of informal waste collectors. Such information has implication for route planning, types of vehicle and transportation of collected waste.

This paper therefore is divided into four parts. The first part is the introduction. The second part is on the different methods of collection of household solid waste. The third part of the paper presents the main findings of the study in the case study locations including the test of hypothesis. The fourth part of the paper is the conclusion.

1. Methods of Collection of Household Solid Waste

On municipal wide level, household solid waste account for about 75% of all generated solid waste (Hoornweg and Bhada-tata, 2012). In the developing countries including Nigeria, it is estimated that about 60% of household solid waste consists of organic materials. The remaining 40% consists of inorganic solid waste of paper, cardboard, plastic, glass, rubber and metals (Coffey and Coad, 2010). The point of collection of household solid waste therefore, is the location where the waste passes from the generator, to the collection authority. This is the point of interface between the service beneficiary and the service provider. The generator of the solid waste is thus responsible for taking the waste to the point of collection, and so, is concerned about the time and effort required and must therefore be willing and able to perform this task. On the other hand, the collection agency is concerned about the cost of collection, operation, access, loading as well as problems that arise when the generator fails to perform his task. Four basic location points are possible where the household generated solid waste could be transferred to the collection agency namely;

1.1 Kerbside Collection: This is in street collection at the property boundary of the generator of the solid waste. Under this arrangement, the collection vehicle with its crew collects household solid waste in containers which have been left at the roadside. Residents need to be informed well in advance under this arrangement about the days on which the collection of the household waste will take place so that they can bring out generated waste in time for collection. This method of household solid waste collection requires effectiveness, regular and well organised service to take the households along, because delays in collection will lead to household's waste being left outside for longer periods of time than necessary, with increased incidence of scattering of the waste by animals and waste pickers. This method appears to be commonly adopted method in the developed world having replaced the back-door approach as labour costs of the latter method have increased.

1.2 Back-Door Collection: Under this method of household solid waste collection, residents are only expected to store their waste in their premises outside the backdoor. The waste collection crew goes into each property, takes out the solid waste container, empties same into the collection vehicle and returns the container to its place. With little or no involvement by the household in the collection process, this method of household waste collection results in increased labour cost. In some areas, the privacy and security issues tend to discourage the consideration of this approach. This approach is used mostly in the industrialised countries but is now being replaced by the kerbside collection method because of the high labour cost involved.

1.3 Community/Street Container: This is in the street collection but at a short distance from the property of the solid waste generator. Under this method of household solid waste collection, the residents are expected to bring their generated waste to the point of the community/street container where the solid waste collection vehicle visits at intervals to remove accumulated waste. The main selling point of this method of collection is that it has the potential to significantly reduce the number of points from which household solid waste has to be collected. The potential cost saving advantage of this approach could however be defeated if the community/street containers are too widely spaced out (longer distance for residents), and poor public acceptance and cooperation. This could result in household solid waste being thrown on the ground to avoid having to be brought to the community/street containers.

1.4 Block Collection Method: This is another form of the in-street method where a solid waste collection vehicle travels a pre-determined route at stipulated intervals, known by the residents. The collection vehicle stops, rings a bell or plays music. On hearing this signal, households bring their solid waste container to the collection vehicle and hands it over to a member of the crew who empties the waste into the vehicle and passes the container back to the householder. The timing of this approach must be such that there is a member of the household at home to bring out their solid waste.

Of the four methods discussed, the Community/Street; and Block Collection methods are often seen as providing the lowest level of service. They also represent the commonest methods of household solid waste collect approaches adopted in most developing countries including Nigeria.

2. Littering and Illegal Dumping of Household Solid Waste

Littering and illegal dumping of household solid waste in the residential neighbourhood of urban areas of Nigeria and other countries in the developing world have become major sources of pollution and pose serious health risks to residents and significantly affect the appearance of the neighbourhoods. A number of reasons may be responsible for the littering and illegal dumping of household solid waste in the urban areas of the developing world. These include:

2.1 Inconvenience with Community/Street Solid Waste Collection Containers: Where community/street solid waste collection containers are inconvenient to use, people may drop their household waste besides them rather than into them. Users of these containers who come later would not wish to walk over the dumped waste to reach the containers so they also deposit their solid waste outside the containers. Unsatisfactory features of the containers could include a height that is inconvenient for children using them, lids or covers of containers

which are difficult for children to open or considered to be unclean so users may not want to touch them;

2.2 Wrongly Located Community/Street Solid Waste Collection Containers: Community/Street solid waste collection containers need to be located within easy walking distances of the residential properties they are intended to serve. In addition these containers must of necessity be located in places that are accessible to the solid waste collection vehicles. Residents often may be unwilling to cross busy roads to reach a community/street solid waste collection container;

2.3 Dumping Waste in Drains: Some residents seem to think wrongly though, that drains are a convenient place for household solid waste. It is assumed that the flowing water will carry the waste away and it will no longer be a nuisance. However, drains are the worst possible place for waste because waste materials block them and provide stagnant stretches of water for mosquitoes to breed and cause flooding (Hoornweg and Bhada-Tata, 2012).

3. Informal Waste Collectors

The rather unsatisfactory system of household solid waste collection in the cities of Nigeria and many countries in the developing world has prompted residents to consider alternative approaches to evacuate household solid waste, including the patronage of informal private waste collectors. Certainly the presence of a vacuum that needs to be filled in the system of household solid waste collection may be responsible for the growth of informal solid waste collection in the towns and cities of the developing world. Informal solid waste collector refers to the person involved in the collection of any substance from the street, or a person who searches for discarded items and collects them (Sentime, 2011).

Informal waste collectors are equally described as people involved in recovering materials to sell for re-use and or/ recycling. The specific place and circumstance pertaining to waste collection seem to determine the different ways of describing informal waste collectors.

In Mexico for example, informal waste collectors are called ‘Pepenadores’ (Medina, 1997), which implies poor people making a living from waste recovery. In Cairo, Egypt, informal waste collectors are known as ‘Zabbaleen’ (Neamatulla, 1998), which is Arabic for garbage collector and those involved are mainly migrants into the city.

In Anambra state, and other states in Nigeria, the cart-pushers are the informal waste collectors involved in the house-to-house evacuation of solid waste and transport same to government approved collection point (Community/Street Container) for a fee.

4. Case Study Area

Anambra state is located in the South Eastern part of Nigeria (coordinates 6.3333° N, 7.0000° E) with a 2012 estimated population of about 4.7 million and more than 60% of the population living in urban areas (UN-Habitat, 2009). The three major urban areas in the state are Awka, the state capital, Onitsha, the commercial centre and Nnewi the industrial hub of the state.

The agency tasked with the responsibility of collecting household solid waste in Anambra state, Nigeria, is the Anambra State Waste Management Authority (ASWAMA) which was established to perform the following functions:

- Clean the streets, remove, collect and dispose of domestic, commercial and industrial waste;
- Remove, and dispose of carcass of dead animals from public places;
- Prepare and update from time to time the master plans for waste collection and disposal in the cities, towns and villages in the state and control resultant waste systems within the state;
- Approve and monitor all waste disposal systems in the state;
- Make provision for waste management services to state agencies' local governments, industries, business entities and private persons within the state by receiving waste at the authority's facilities pursuant to contract agreement between the authority and such other party;
- Issue, renew and revoke licence of private waste collectors; and
- Do all such acts as are necessary or incidental to the proper discharge of its duties under the law (Anambra State of Nigeria, 2011).

To perform its function under the above law in terms of collection of domestic solid waste from residential areas, the ASWAMA has provided community/street collection containers at strategic locations along the streets in the residential neighbourhoods where residents are expected to convey generated household solid waste and put same into the containers. The agency hauls such waste in its vehicles to the town's final solid waste dump site.

5. Research Methodology

The research methodology adopted in this study is largely a quantitative design, specifically a sample survey approach to quantitatively determine the percentage of generated household solid waste removed by different means including that collected by informal private waste collectors and the distance to approved community/street solid waste collection containers which households have to cover in the residential neighbourhoods of Awka, Onitsha and Nnewi. Another justification for the choice of a quantitative research approach may be explained by the fact that evidence from the literature supports the use of

quantitative methodology for such a study (Epp & Mauger, 1988; Yusof *et al*., 2002; OECD, 2008; Kayode & Omole, 2011; Abbasi *et al*., 2013). The key target population are the household heads to obtain data on household solid waste collection and distance to community/street collection containers. In the absence of a frame of all household heads in the urban areas studied, the research adopted a simple random sampling system for selection of household heads to be enumerated in the residential neighbourhoods of Awka, Onitsha and Nnewi The simple random approach was also adopted to overcome selection problems arising from the reluctance of some households at being enumerated. A total of 2 field assistants were employed and trained for the enumeration of the household heads.

The study used fully structured questionnaires as the instrument for data collection. This was piloted to validate and sharpen the questionnaires before the final administration on the sampled population was carried out. The questionnaire included questions on the different system adopted by households at collection and disposal of generated household solid waste and the distance in metres to community/street solid waste collection containers.

The direct face-to-face approach of data collection was adopted to collect data on solid waste from the sample respondents. However before the main interviews were conducted, the data collection instrument (structured questionnaires) was piloted (pre-test) to validate the instrument and make sure that the respondents would understand the questions and procedures for data collection. It also served as one of the means for training the 2 field assistants in the data collection procedure. After the pilot of the data collection instrument, the main interview of the respondents was then conducted.

The data collected from the above exercise was coded, collated and imputed into the Statistical Package for the Social Sciences (SPSS) 15 software for analyses and the production of figures (to present and describe results) as well as ANOVA tables to compare mean distances to the community/street solid waste collection containers in the case study towns of Awka, Onitsha and Nnewi, Anambra state, Nigeria..

6. Results and Discussion

Figures 1 provides a breakdown of how sampled households in Awka remove their generated household solid waste. The figure shows that 34% of sampled households indicated that they take their generated household solid waste to the neighbourhood community/street collection containers for the public agency responsible for final collection to collect and convey such waste to the town's final disposal point. Figure 1 equally shows that about 16% of sampled households employ the services of informal private solid waste collectors to pick up their

generated household waste from their homes and convey such to the community/street collection containers.

Figure 1 equally shows that 40% of sampled households either dump generated household solid waste in the bush, burn it or dump it in public drains.

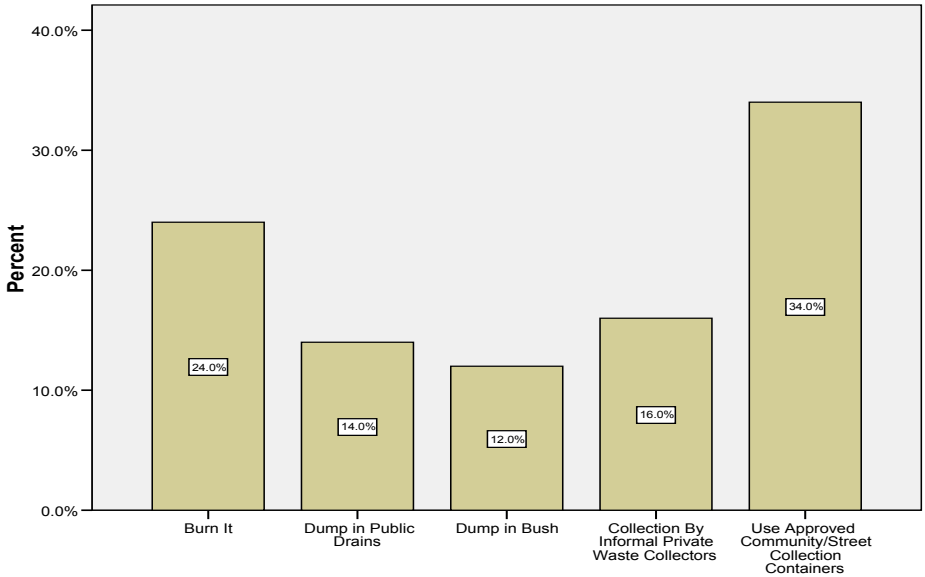

Figure 1 Household disposal of generated solid waste in Awka

Figure 2 provides a breakdown of how sampled household in Onitsha remove generated solid waste. From the table 50% of sampled households employ the services of informal private solid waste collectors to convey such waste to the community/street collection containers. From Figure 2, only about 14% of households prefer to carry generated household solid waste to the government provided community/street collection containers. From figure 2, 36% of sampled households dispose of generated household solid waste either by dumping it in public drains, burning it or dumping it in the bush.

The implication of the information is that the majority of households in the town do not find the use of publicly provided community/street solid waste collection containers as a convenient means to remove generated household solid waste. It does appear that they find the use of informal private waste collectors and other means of disposal more convenient removal and disposal approaches in the town. A general impression from the foregoing is that households in Onitsha, the major economic centre of Anambra state appear not to be well served by the

government provided community/street solid waste collection containers or outright rejection of such collection method.

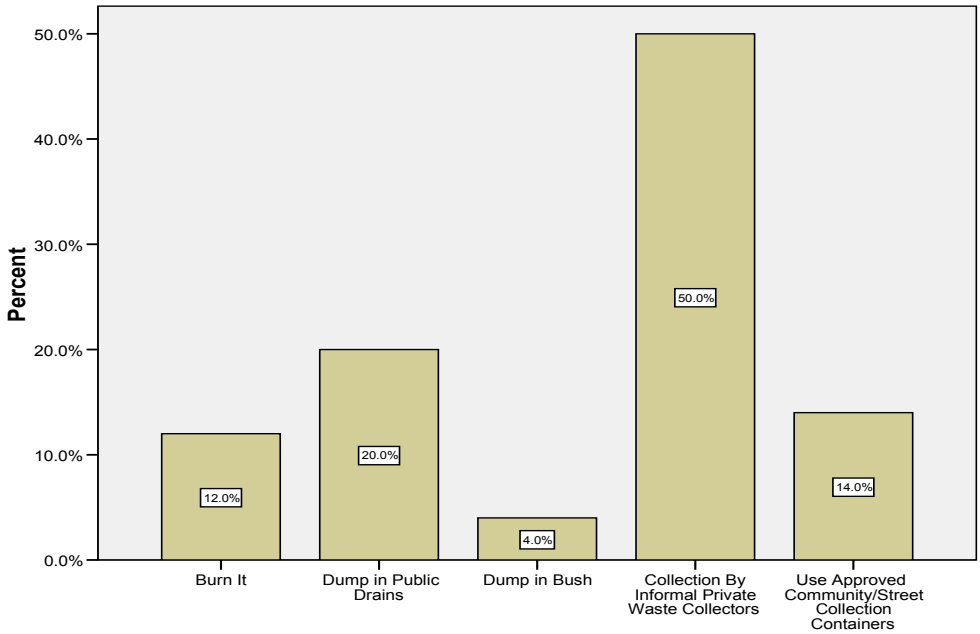

Figure 2 Household disposal of generated solid waste in Onitsha

Figure 3 provides a breakdown of how sampled households in Nnewi, the third town in our area of study, Anambra state, Nigeria remove generated solid waste from their homes.

From Figure 3, 44% of sampled households in Nnewi, Anambra state, the main industrial centre of the state, employ the services of informal private solid waste collectors to remove generated household waste, while 16% of sampled households take generated household solid waste to government approved community/street collection containers. The remaining 40% of households either burn, dump in public drains or dump in the bush, generated household solid waste in Nnewi. A significant point to note here is that in the three towns, sampled residents appear to employ the services of informal private solid waste collectors to remove generated household solid waste. Equally, sampled households appear to 'indiscriminately' dispose of their generated solid waste either in the bush, burn it or dump it in public drains. Another important observation from the sampled households in the three towns is that only in Awka, the state capital do we observe that more than 30% of sampled households use the government provided

community/street collection contains as points of collection for generated household solid waste.

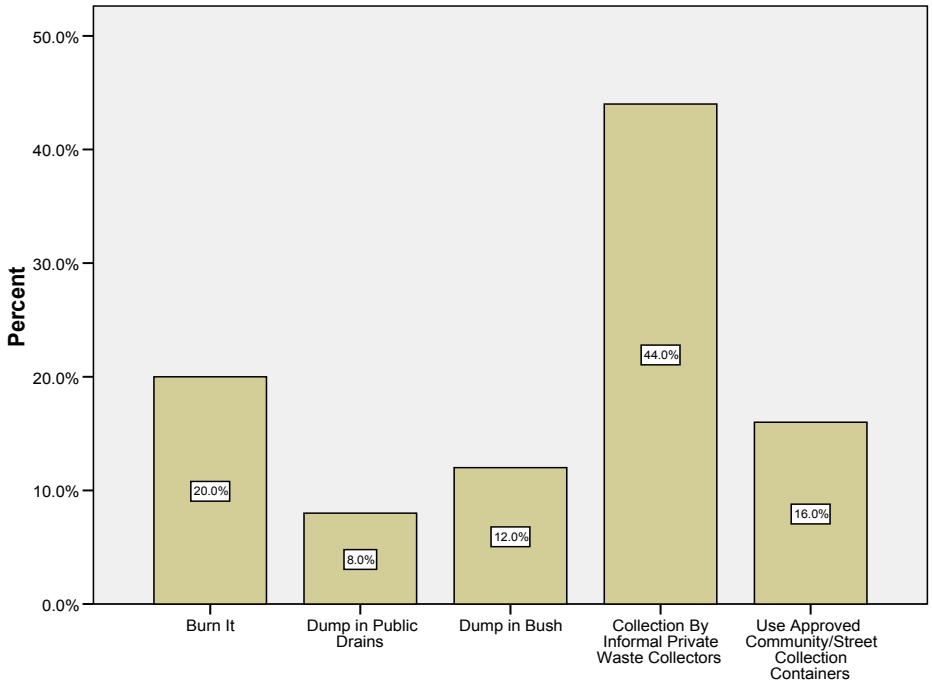

Figure 3 Household disposal of generated solid waste in Nnewi

It is important at this point to see if we could identify an explanation for the disparity in the use of government provided community/street solid waste collection contains by sampled households in the three major towns in Anambra state. Table 1 is a one way ANOVA *F*-test table. The null hypothesis is that the samples of the distance from households in the study areas come from populations with the same mean. From table 1 we see that the *p*-score is so low that we reject the null hypothesis of no difference. By rejecting the null hypothesis, we have decided that at least one of these populations has a mean that is not equal to the others.

Table 1 One way ANOVA Analysis of distance to community/street collection containers

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	77117177	2	38558588.667	538.736	.000
Within Groups	10521130	147	71572.313		
Total	87638307	149			

The *F*-test itself fails to tell us which of the populations, and how many, differ. The *F*-test also fails to tell us which of the possible pairwise (sub-groups) differences between samples are significant. To determine which samples are significant, we turn to a set of techniques called post-hoc comparisons to find out which of the populations differ(s) from others. Table 2 provides a comparison of means for each town against other towns in the study area.

Table 2 Post Hoc multiple comparisons of mean distance of the three towns
Dependent Variable: Distance to Community/Street Collection Containers Scheffe

(I) Towns	(J) Towns	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
Awka	Onitsha	-54.200	53.506	.600	-186.52	78.12
	Nnewi	-1547.400*	53.506	.000	-1679.72	-1415.08
Onitsha	Awka	54.200	53.506	.600	-78.12	186.52
	Nnewi	-1493.200*	53.506	.000	-1625.52	-1360.88
Nnewi	Awka	1547.400*	53.506	.000	1415.08	1679.72
	Onitsha	1493.200*	53.506	.000	1360.88	1625.52

* The mean difference is significant at the .05 level.

The first row in table 2 compares Awka with Onitsha and Nnewi. The second row compares Onitsha with Awka and Nnewi while the third row compares Nnewi with Awka and Onitsha. The important aspect to table 2 is the Sig. column which provides the exact significance for the difference between any two means.

Where this is less than 0.05, SPSS places an * (asterisks), next to the value in the mean difference column, indicating a significant difference between the means of the two samples being compared, at the SPSS default significance level of 0.05. Collecting these * (asterisks) together we can see that a significant difference exists between the means for each of the following pairwise (sub-groups) comparisons:

- Awka by Nnewi

- Onitsha by Nnewi

In other words, for each of these pairwise (sub-group) combinations, we can reject the hypothesis that the mean distance from the residences of households to the community/street collection containers are the same.

The difference in the mean distances to community/street solid waste collection containers in the three urban areas of Awka, Onitsha and Nnewi in Anambra state, Nigeria helps provide explanation for the patronage by households of informal private solid waste collectors in the areas studied. Thus the urban areas with higher patronage of informal private solid waste collectors; Onitsha and Nnewi appear to have higher mean distances to community/street solid waste collection containers than Awka, which has highest patronage of government provided community/street solid waste collection containers. Therefore, it does appear that the lower the mean distance to community/street solid waste collection containers, the higher the use of government provided community/street solid waste collection containers in the towns studied. Conversely, the higher the mean distance to community/street solid waste collection containers, the higher the patronage by households of informal private solid waste collectors.

We equally observe that the higher the mean distance to government provided community/street solid waste containers, the higher the incidence of 'indiscriminate' disposal of household generated solid waste into the bush, public drains or the incidence of burning such waste.

The study has further demonstrated that outside the Anambra state capital of Awka, in the other urban areas such as Onitsha and Nnewi the distance households need to go to a community/street solid waste collection container appears to be much longer. Distance to community/street containers is a very important variable for assessing the effectiveness or otherwise of public waste collection and management agencies in the urban areas of the developing world. The evidence presented by the above study in Anambra state, Nigeria using the urban areas of Awka, Onitsha and Nnewi, does point to an ineffective system of collecting generated household solid waste by the government agency tasked with that responsibility reflected in the 'indiscriminate' disposal of household solid waste and high incidence of patronage of informal private solid waste collectors.

Improvement in the system of solid waste management by the Anambra State Waste Management Authority (ASWAMA) must begin with the reduction of the distances households need to walk to reach a community/street solid waste collection container within residential neighborhoods. The mean distance the agency should endeavour to achieve must be much lower than the current distance as observed in Awka, the Anambra state capita which appears to be the lowest of the three towns.

This the agency can achieve by providing more of such community/street solid waste collection containers closer to residential areas in the urban centres of Anambra state than the evidence currently suggests. With this in place, households are then more likely to take to the community/street solid waste collection containers their generated solid waste for collection by the Anambra State Waste Management Authority and a better and more effective performance by the agency would be the overall outcome.

Conclusions

The study has demonstrated that informal private solid waste collectors play a major role in the cities of Anambra state, Nigeria. Evidence from the three urban areas of Awka, Onitsha and Nnewi, shows, that the informal private solid waste collectors remove generated household solid waste from a large percentage of households, in these areas. The study further shows that the patronage which these collectors enjoy differs across the three urban areas with Onitsha and Nnewi demonstrating higher levels of patronage of the informal private collectors than Awka the state capital. There is also evidence to show that the higher the mean distance the households have to walk to a government provided community/street solid waste collection container, the more likelihood that residents would patronize the informal private waste collectors to evacuate generated household solid waste. The policy implication for a more effective solid waste collection of household solid waste in the urban areas of Anambra state therefore, is on the considerable reduction of the mean distance to community/street solid waste collection containers, than the current distance suggests. This can be achieved through the provision of more of the community/street collection containers much closer to the households they are intended to serve.

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CLIMATE CHANGE, URBANIZATION AND LIVELIHOOD PERSPECTIVE OF INDIGENOUS FISHING COMMUNITIES OF MUMBAI, INDIA

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Key words: fishery, urbanization, climate change, pollution, Mumbai.

Abstract: This study is an attempt to derive the socio-economic implications of climate change and other environmental issues pertaining to fishing communities residing in and around Mumbai, India. A substantial number of populations in Mumbai city are the fishing communities, popularly known as 'Koli'. They are the earliest inhabitants of the city. Coastal cities are most productive as well as most vulnerable to environmental changes. They support a number of economic activities which include fishing, agriculture, urbanization, real estate, tourism, transport, oil exploration etc. As a result, the anthropogenic pressure on coastal cities is increasing. Koli communities in Mumbai encounter diverse socio-economic and climatic pressures including sea level rise, floods, storms, etc. The implications of climate change on Koli communities as well as other environmental issues pertaining to fishing villages in Mumbai are discussed in detail in this study. Five fishing villages from Mumbai are selected for a primary study based on a structured questionnaire. Nearly 200 households are surveyed in a period over six months in 2011-12, finally 182 households information is considered for further analysis. On the basis of the findings, this study suggests that issue of lack of asset formation and financial insecurity among young fishermen may be taken care by linking the fisheries societies in Mumbai and in other regions with the support from local governments. The benefits of subsidies, insurance may be distributed progressively based on their financial needs to all fishermen rather than benefiting the large scale fishermen alone.

Introduction

India has more than 8000 km long densely populated, fragile and highly productive coastal ecosystem which includes a huge array of marine biological

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diversity and the largest number of commercial fish species in the world. Fish is an important source of food as well as employment, income and foreign exchange for India (ICSF, 2001). The fishery sector supports a diverse range of livelihood activities, from production and processing to marketing and ancillary functions. Traditionally marine fishing was a group activity, with each member contributing according to their capacity. However, presently there has been a change in fishing operations from subsistence based traditional occupation to profit oriented business, which has seriously threatened traditional skills, knowledge, and employment of artisanal fishermen (Salagrama, 2006). The diffusion of new technologies has benefited only a few fishermen in the sector. Geographical and occupational migration by fishermen in search of livelihood is increasing, and much of this burden falls on the women and younger generations. The change in climate will further affect the fish distribution which will lead to increase in fishing efforts (IPCC, 2007).

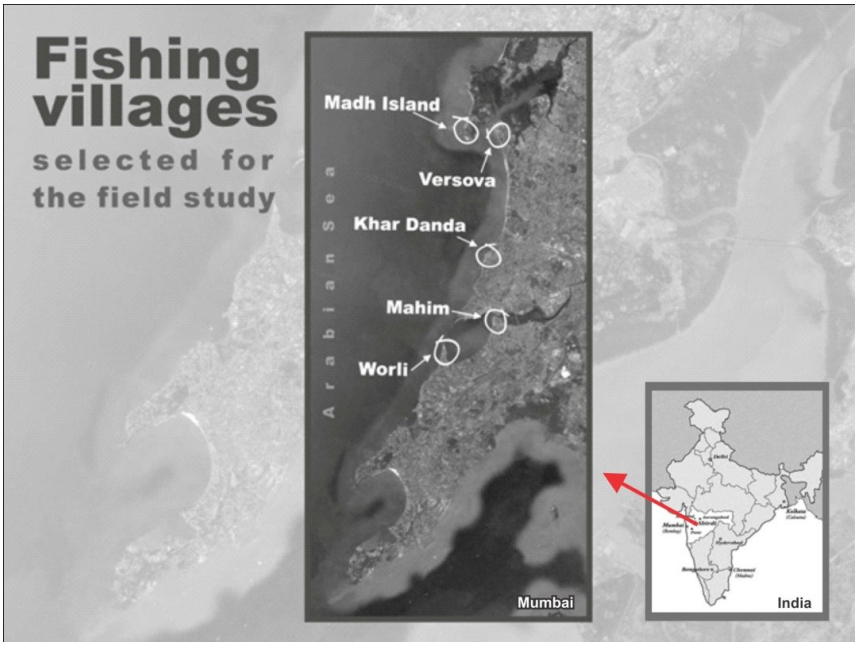

Fig. 1. Fishing village surveyed for the present study.

The Energy Research Institute (TERI), New Delhi has estimated that a 1metre Sea Level Rise (SLR) will affect 5763 km^2 (or 0.41%) combined area of the coastal states in India (TERI, 1996), since coastal fishing communities live close to the

sea, they are going to bear heavy burden of rising sea level. Fishing communities are also known for their reactive or adaptive nature (Coulthard, 2008). Therefore it is appealing to study the implications of climate change and other environmental changes, their marketing behavior and other social and economic aspects of these indigenous fishing communities.

This study is both descriptive and empirical in its framework. Mumbai is the most vulnerable coastal district in India in terms of its physical and economic exposure to climate change (TERI, 1996). The unprecedented changes in rainfall frequently create problems. Such as flooding, storms etc to the city. The fishing communities residing close to the sea and in low lying areas are the most affected. The livelihoods of fishing community get threatened due to unfavorable socio-economic and climatic conditions which make them weak to further cope with the city's living condition. Therefore this study selects Mumbai as its study area and coastal fishing communities living in Mumbai to undertake a household level primary survey. Figure 1 below shows the pictorial view of Mumbai and the fishing villages surveyed for the present study.

1. Socio-economic Profile of the Fishing Households

Socio-economic characteristics of the households play a very important role in describing and assessing the vulnerability of households to climate change. The first five sections of the questionnaire deal with various household socio-economic parameters like (1) Households' demographic information, (2) Occupation, (3) Family income and expenditure (4) Households' physical assets. In the following table 1 the above issues are presented and analyzed subsequently.

Table 1 presents the descriptive statistics on the demographic features of the respondent surveyed. A majority of the respondents are young with 64.3% falling within the age group of 31-50, the mean age being 43. A majority of them, about 89%, are male respondents and head of the household. Women in the fishing villages keep themselves busy in household works as well as in selling and marketing activities, so it was difficult to speak with them. Male members of the households take a break after their fishing trip and during this time their responses in the predesigned questionnaire are recorded. In Koli households, marriages are held at a very young age, so that as the young fisherman go for fishing, the wife takes charge of marketing, thus almost 93% fishermen in the survey are married. Another reason for this could be the large proportion of nuclear family pattern in the fishing villages. In the survey 68% of the families are nuclear family and only 32% are joint families. The nuclear family heavily depends on its female members. In the survey only 15% of the respondents are found as illiterate, whereas nearly 75% of them studied up to matriculation. In most of the fishing villages the government-run schools are up to matriculation (10th standard). The fishermen

forced their children into fishing from an early age, mostly at the age of their matriculation. In terms of religion, 86% of the respondents surveyed are 'Hindu Kolis', and the rest are 'Christian Kolis' Chirstian Kolis mostly reside in the villages like Madh and Mahim.

Tab. 1. Demographic characteristics (total N=182)

Variable	Frequency	Percentage
Age (in Years)		
Less than 30	23	12.6
31-40	64	35.2
41-50	53	29.1
51-60	29	15.9
Greater than 61	13	7.1
Sex		
Male	162	89.0
Female	20	11.0
Marital Status		
Married	169	92.9
Unmarried	13	7.1
Education		
Illiterate	28	15.4
Primary	62	34.1
Matriculation	72	39.6
Higher Secondary	18	9.9
Graduate and above	2	1.1
Religion		
Hindu	157	86.3
Christian	25	13.7
Caste		
Scheduled Caste (SC)	11	6.0
Scheduled Tribe (ST)	22	12.1
Other Backward Caste (OBC)	6	3.3
Special Backward Caste (SBC)	143	78.6
Type of family		
Nuclear Family	124	68.1
Joint Family	58	31.9

Source: Field Survey (2011-12)

2.1 Occupation

Majority of the respondents (87.4%) surveyed are active fishermen and fishing is the full time occupation for nearly 98% of the respondents. Very few respondents consider fishing to be a part time occupation and work in other sectors like, boat making, and do businesses or work in private sectors. For 11.5% of the respondents, mostly women headed households, those who do not possess any boats, for them marketing of fish is the major occupation. The women members purchase fish from others in the village and sell it in nearby markets. Net making and fish shed collection are major fishing allied occupations, however nowadays migrants from other parts of the country as well as from Maharashtra are increasingly involved in these activities as a result of which, fishermen especially women members in the fishing households are losing their traditional job. Continuous reduction in fish availability and increase in competition among fishermen is also forcing young population in fishing villages to look for other occupations. Table 2 shows the frequency of various occupations of the respondents.

Table 2. Occupation of the respondents

Occupation	Frequency	Percentage
Fishing	159	87.4
Marketing	21	11.5
Net-Making	2	1.1
Occupation type		
Full time	176	96.7
Part time	6	3.3

Source: Field Survey (2011-12)

2.2 Households' Income

Fishing is the primary and major source of income for 87% of the households surveyed and for 97% of the households fishing is the full time occupation. The minimum income from fishing is Rs. 40,000 per year/per household and the highest income is Rs. 2, 50, 000 per year/ per household with mean income of Rs. 92,280 and median income of Rs. 80,000. The following (Figure 2) shows that only 5.5% of the respondents surveyed have observed an increase in their income, whereas over 19% of the households observed a decrease in their income over the years. Over 51% observed a moderate rise in income.

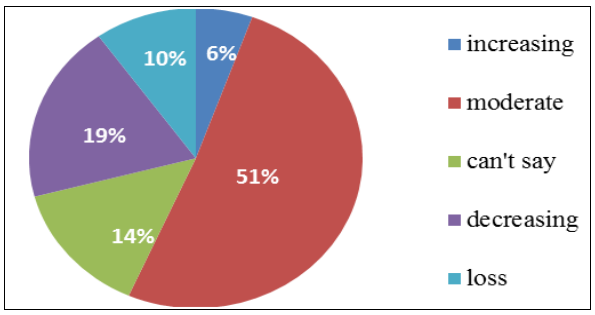

Figure 2. Nature of income over the years from fishing and related activities; Source: Field Survey (2011-12)

2.3 Households' Amenities and Assets

The availability of basic household amenities like house and other physical assets including boats, types of boats, and types of nets are very much important in defining the vulnerability of fishermen. The characteristics of the dwelling/type of house (Katcha/Pucca) define the resilience/adaptive capacity of households to flood, storm and SLR. Fishing villages are situated very close to the sea and are very often affected by high storm, cyclones and flood. Although most of the houses in the fishing villages surveyed are Pucca (51.6%) and Semi Pucca (48.4%), they are often affected by floods and high tides. In Mahim a few of the households have to vacate their house in the month of June and July because of the high tide. The houses in Koliwada are very small. Fishermen usually possess huge fishing equipments including fishing nets, plastic containers, oil containers etc. Fishermen are losing their traditional place to store all these equipments including the places they used to dry fish and berth their boats. The dry fish business is an alternative business but it is lost completely. There are increasing cases of theft of these equipments in the fishing villages. Fishermen are losing these places because of the increase in urbanization and development projects near the coast. The fishermen also do not have property rights on the land they are living, although they are living in these places for a long time. Fishermen housing schemes, which are planned earlier (GOI, 2004) are not properly implemented in the fishing villages.

The other household amenities like electricity, drinking water, and telephone/mobile connection are easily available to fishermen and all the households surveyed have electricity and drinking water facilities. However, fishermen are not getting any subsidies towards the electricity and drinking water which adds to their financial burden, especially for small and poor fishermen. Radio, which was earlier considered as an important source of news and communication is now substituted by mobile phones, television and other

electronic equipments like GPS, fish finder etc. From the survey 64 fishermen are found using mobile phone, 37 use satellite phone, 17 use GPS (Figure 3). These instruments also help them in accessing information related to climate, storm, cyclones, winds, etc. Others include, television, radio etc.

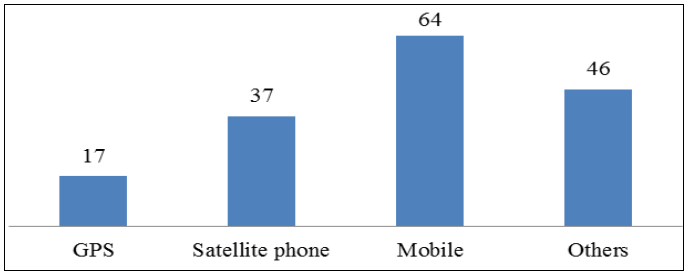

Fig. 3. Types of communication gadgets fishermen use;
Source: Field Survey (2011-12)

Boat is the primary factor of production for fishermen and the types/categories of boats reflect the economic well being of the household. Boats are divided here into three categories: mechanized, motorized and non motorized/country boats. Table 3 shows that 164 households having boats, out of which 53 (32%) possess mechanized boats, 96 (58%) have motorized boats and only 15 (9%) have country boats. 18 respondents do not have boats at all. Versova and Mahim having more mechanized boats, on the other hand the fishermen from Khardanda, Madh and Worli possess more motorized boats. Fishermen get subsidies in the form of soft loans towards making mechanized boats. But there are many reasons such as competition, increasing cost of labour, fish depletion, climate change etc. which forced most of the fishermen to sell their mechanized boat. They are now fishing through motorized and country boats in nearby waters.

Table 3. Types of boats

Types	**Own Boats**	
	Yes	**Total**
1. Mechanized	53 (32.3%)	164 0.1%)
2. Motorized	96 (58.5%)	
3. Non-motorized/country boats	15 (9.1%)	
4. No boat	18 (9.9%)	18 (9.9%)
Total		**182 (100%)**

Source: Field Survey (2011-12)

2.4 Households' Consumption Expenditure

Consumption pattern of the household is one important factor for measuring vulnerability. The study by Sumaila et al. (2011) posit that the capital costs, that is, the cost of vessels, fishing gear, processing plants and so on, would also be affected by climate change (by involving additional capital for fishing and processing operations to adapt to climate change impacts). The poor families generally lack adequate means to cope with climate change and other problems. On the other hand, rich households suffer less damage due to their financial capabilities to withstand the damages and due to their high adaptive capacities. The household expenditure is here divided into two categories: consumption expenditure of household on primary goods and utility bills such as, food, water bill, electricity, health etc. and expenditure towards fishing like, boat repair, net repair, fuel cost, labour cost etc.

Table 4. Annual household consumption expenditure and fishing costs (in Rupees)

	Mean	Median	Minimum	Maximum
Food	57037.91	50000	5000	150000
Drinking water	859.61	900	100	3000
Health	2191.48	1000	0	50000
Education of children	6059.66	1500	0	100000
Electricity	7497.80	7200	1000	18000
Other household expenditure	6137.363	5000	1000	50000
Annual fishing costs				
Boat repairing	24529.95	11000	0	200000
Net repairing/purchasing	18266.48	15000	0	100000
Fuel (Petrol or diesel)	250531.3	75000	0	1500000
Transport	506.60	0	0	10000
Storage	14213.19	2000	0	75000
Labour	107601.6	75000	0	600000

Source: Field Survey (2011-12)
Note: '0' here shows those households who do not possess a boat

Table 4 provides the details of annual household expenditure. The mean expenditure on food for the respondents is Rs.57,000 with minimum expenditure of Rs.5000 and maximum of Rs.1,50,000. The mean annual expenditure for boat repairing is close to Rs. 25,000 per year. Every year before the starting of fishing season, fishermen spend a huge amount on repairing and making the boat ready for fishing. The annual mean expenditure towards net repairing is Rs. 18,000. Due to change in wind currents, and due to increase in storms, fishermen's spending on net repairing is increasing. The average annual expenditure on fuel is close to

Rs.2,50,000 with minimum expenditure of Rs.75,000 and maximum expenditure of Rs.15,00,000. The expenditure on storage and ice is also increasing with the rise in temperature and climate, the mean expenditure on storage is Rs.14,213 yr. Similarly the annual mean expenditure on labour is Rs.10,7600 yr.

2. Marketing Issues

Marketing of fish is traditionally confined to Koli women. However, with the entry of middlemen to the fishing business there is an increase in the export of fish and availability of transport and storage facility. In the survey 66.5% of the respondents are selling fish to middlemen. The major reason for selling fish to middlemen is that most of the fishermen borrow money from them (Figure 4). Fishing is a seasonal business and every year for a particular period, generally in monsoon time, fishermen do not go for fishing. During that period fishermen depend upon their savings as well as borrow money from middlemen. Similarly at the start of the fishing season they also borrow money from middlemen for purchasing fishing equipments. Sometimes fishermen do not want to spend money on transporting fish to the market, so the middlemen reach at the fish landing site and directly buy fish from fishermen. The price of fish also depends on market forces and there is absence of any regulation from the government. Therefore most of the time middlemen cheat fishermen by paying very low price and later selling fish at a higher price in other markets. Sale of dry fish is also one of the major sources of earning for fishermen. The small fish and other fishes having much lesser value are usually dried and sold in the market. However, this business is also declining, only a few fishermen from Madh and Khar village are still doing this dry fish business.

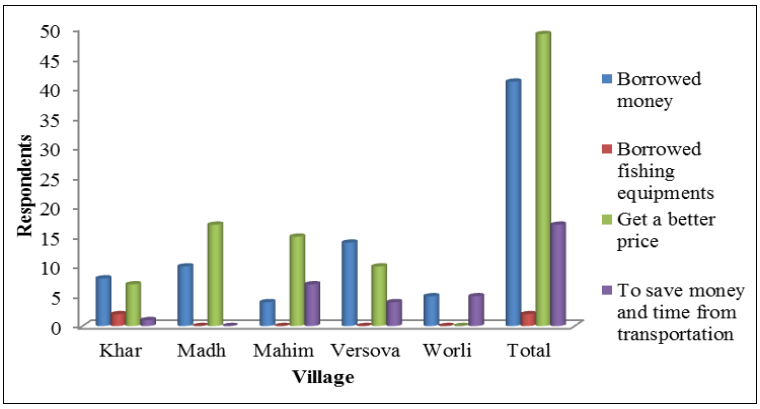

Fig. 4. Reason for selling fish to middlemen; Source: Field Survey (2011-12)

3. Health Issues

Health is an important socio-economic aspect of the fishery based livelihood. The fishing villages are very congested and there is little open space left in the area. The slum like places are always exposed to diseases like malaria, dengue etc. Climate change is also one of the major reasons for increasing health risks in fishing villages (CMFRI, 2010). In case of diseases and illness fishermen prefer to go to public hospitals, however in some villages like Madh and Khar a majority of fishermen prefer to go to private hospitals. The medical facilities provide by the government are not available nearby, rather there are a number of private clinics and fishermen prefer to go to nearby clinics in case of emergency. However, these private clinics charge more and they have their own timings.

4.Urbanization

Rapid industrialization, urbanization and a lack of control over the dumping of chemicals and pollutants into the Arabian Sea are some of the major causes of concern for fishing villages. As the fishing villages are situated close to the sea, all these wastes often reach the fishing villages causing serious health and other issues. According to the study conducted by National Institute of Oceanography

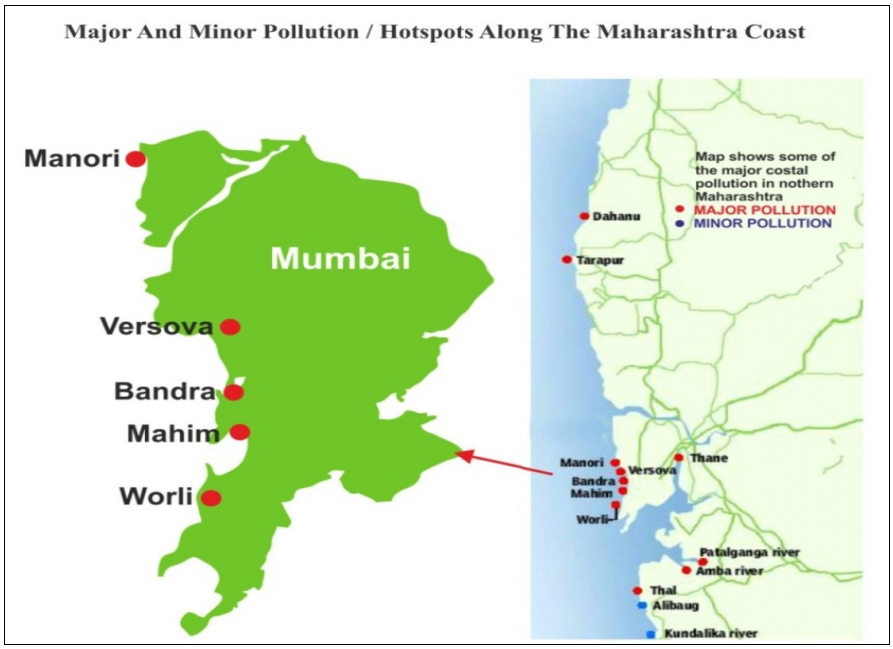

Fig. 5. Major and Minor pollution along the Maharashtra coast

(NIO) for the Maharashtra Pollution Control Board (MPCB), the entire coast line of Maharashtra is the most polluted coastline in India (TOI, 2010). The area from Dahanu to Mulund, along the northern coastline of Maharashtra is most polluted due to the presence of organic substance (chemical and domestic pollutants) in the water. There is also more petroleum contamination in the creeks of northern Maharashtra as compared to the South. Three of the five fishing villages selected for the current study (Versova, Mahim and Worli) are among the major polluted region found in that study (figure 5).

According to 95% of the respondents urbanization is a major problem affecting their livelihood. Water pollution, destruction of mangroves, increase in construction activities and increase in port activities are some of the related issues of rapid urbanization and industrialization. Due to this, the fish catch in the creeks is less than in open-shore waters. There could be a risk to the breeding of commercially important fish in the long run seriously affecting the natural balance of fish availability. In the following Figure 6, the respondents' ratings of the issues of urbanization are presented.

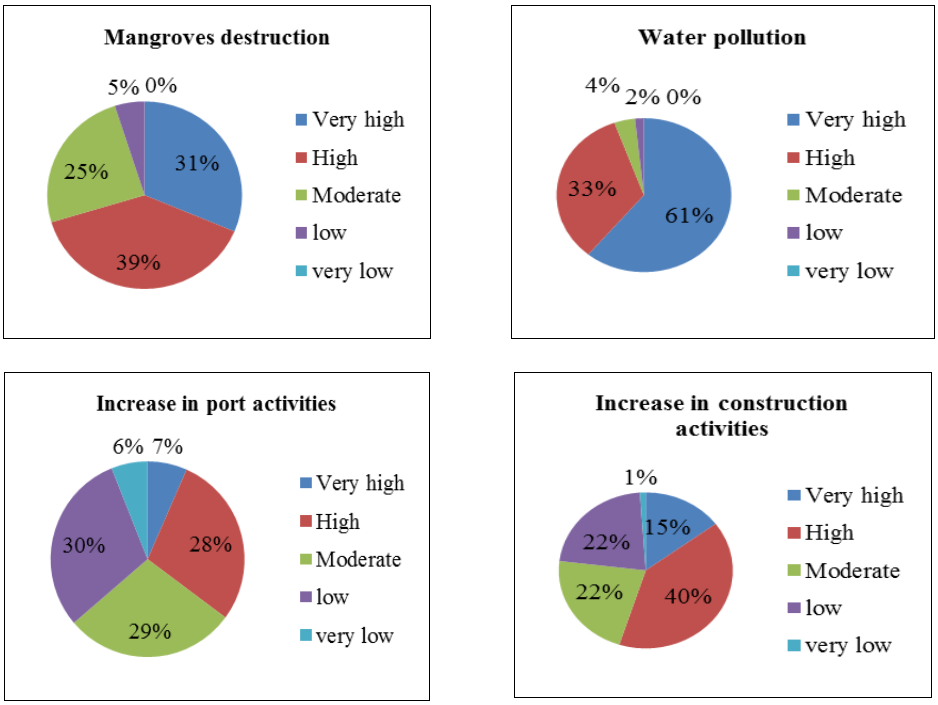

Figure 6. Urbanization issues; Source: Field survey (2011-12)

Findings and Conclusion

Descriptive analysis of the primary survey data shows that fishermen in Mumbai are young (mean age year 43) and educated (75% of the respondents studied up to matriculation), and for majority of them (98%) fishing is the only and full time occupation. However, there is a huge disparity in the level of income, and different fishing practices are adopted by fishermen in different fishing villages. For example in Versova and Mahim fishermen used more mechanized boats whereas in Madh, Worli and Khar fishermen possess more motorized boats. The category of boat is one important factor which decides the economic well-being of the fishermen. The analysis of expenditure data of fishermen reveal that the expenditure towards boat repairing and net purchasing including the costs of fuel and labour are high and affecting financial stability of the fishermen in Mumbai. The entry of middlemen and migrants into fishing business is affecting the Koli women, in many parts of the city women members are losing their traditional job of selling fish. Male members of fishing household suffer from more health related problems compared to others. This could be because of their hard labour, and exposure to different types of weather, rainfall, temperature in the sea. Though there are several government run hospitals in and around Mumbai, fishermen often preferred to go to the private clinics in their neighborhood. The clinics do not follow a particular time table, and in case of emergency fishermen are finding it difficult to get immediate treatment. The issue of urbanization and the observation of fishermen towards related impacts of climate change like water pollution, destruction of mangroves show the seriousness of the problem. Water pollution is a major challenge for fishermen (61% ranked the problem very high) and since fishermen depend mostly on sea, the polluted coastal water is affecting them seriously in terms of decrease in fish availability, increase in heath issues etc.

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THE STUDY OF STAGES AND OPERATIONS INVOLVED IN THE PRESERVATION AND RESTORATION OF TWO XIX-th CENTURY ICONS, ON WOODEN SUPPORT

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Key words: icons, stopping xylophagous attack, consolidations, reintegration, restoration

Abstract. The paper presents the stages and the operations involved in the preservation and restoration of two icons on wooden support, from the XIX-th century, which are part of the heritage of the ”Sfinții Arhangheli Mihail and Gavriil” church, from Galați. The two icon have inventory numbers as part of the collection as followed: 112 for the first icon and 113 for the second one. Both icons have the same theme, ”The Grieving Mother from Rohia” and are made by anonymous painters in egg tempera, on lime wooden support, without ground. Being part of the same collection, they were deposited in the same place and as a direct consequence, they suffer from similar deteriorations and degradations that affect both the support and the painting layer. Both panels are attacked by xylophagous insects and the painting layer has detachments, gaps, cracks, clogged dirt and a cracked and degraded varnish layer. Ten samples taken from the already detached areas were analyzed by optical microscope, SEM-EDX and micro-FTIR. Based on the chemical elements identified in the EDX spectrums, the pigments used to create the painting layer are: ultramarine natural blue Na8-10Al6Si6O24S2-4, carbon black, earth green, K[(Al,FeIII),(FeII,Mg)](AlSi3,Si4)O10(OH)2, ocher (FeO), burned or natural umber Fe2O3· H2O + MnO2·n H2O+ Al2O3, lead white (2PbCO3·Pb(OH)2) and yellow iron oxide (Fe2O3·4H2O). It was also determined that the gold leaf usually used in byzantine icons was replaced in the case of both icons: the icon number 112 has silver leaf covered with varnish, while the halo of the icon number 113 was created with yellow metallic pigments (realgar or orpigment).The pigments were also identified by determining specific peaks in micro-FTIR spectrums. For natural ultramarine blue the peaks between 628 – 724

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cm-1 were assigned; the peaks in the interval 795 – 887 cm-1 confirm the presence of carbonates (calcium and lead based). The earth green pigment (aluminum – silicates) had the peaks between 1464 – 1599, while the carbon black pigment was confirmed by the peaks in the interval 921 – 1060 cm-1. After the pigments and the materials used by the author were identified, the restoration process begun with the following stages: consolidation of the painting layer (fish glue 8% and japanese paper), stopping the xylophagous attack (encapsulation with nitrogen), consolidation of the wood supports (colophon and wax, 1:1), cleaning the painting layer (ethylic alcohol and distilled water, 1:1), filling the gaps and reintegrating the fillings in tratteggio, all followed by the process of varnishing the two icons.

Introduction

The two icons part of ”Sfinții Mihail and Gavriil” church collection, from Moscu village, Galați, are very similar. Both icons have the same theme, and that is ”The Grieving Mother from Rohia”. The structural composition is the same for both icons, the only significant difference being the shape of the lower scenes of the icons: the icon number 112 has square lower scenes while the second icon with inventory number 113, has round medallions. Both icons are painted in neobyzantine style using egg tempera and the colors used are the same, the general chromatic impression offered by the two art pieces being quite similar: the cloak of the Virgin Mary is dark, surrounded by a green ocher background that becomes darker to the edges of the panels.

Although they have these similarities and are painted in the same period of time, the two icons are done by two different authors, as proven by the different technique used in painting the face of the Mother and the different writing style [1].

Fig. 1. The Grieving Mother from Rohia nr. 112:a – the front of the icon; b – the back of the icon

Fig. 2. The Grieving Mother from Rohia nr. 113: a – the front of the icon; b – the back of the icon

1. Storage environment and the state of conservation

The environment were the two icons were kept has a significant importance on their state of conservation. The high values of humidity (65% - 85%) and temperature (18° – 25^oC) allowed for the xylophagous attack to begin. Also the fluctuations of these two climate factors have subjected the wood supports and the painting layers to tensions. These tensions were caused by the continuous exchange of water between the wood supports and the environment, in order to obtain a fluid balance. The repeated tensions lead to crack in the mass of the wood and in the painting layer [2-4].

1.1. The state of conservation

Because the icons were kept in the same improper environment regarding the stability of atmospheric factors (temperature, humidity), the two icons suffer from a series of similar deteriorations and degradations that require establishing a restoration and preservation protocol.

The two icons are made on lime wooden panels: the one for the icon number 112 is made out of two boards that are kept together by two sparrow crossbeams, from side to side of the panel and the panel of the icon number 113 is made out of three boards, locked tight by a frame. Both the systems that keep the panels together and the panels themselves, have suffered, beside from the xylophagous attack, from a series of deteriorations and degradations. For example, the deteriorations are: boards distancing from each other (fig. 3), cracks, fly holes (fig. 4) support missing due to improper handling and structural weakness caused by insect attack (fig. 5) and the degradations are clogged dirt and wood changing color.

The two painting layers also suffer from deteriorations: cracks, gaps, detachments (fig. 7), fly holes and degradations like clogged dirt (fig. 6), browned varnish and blisters [6-10].

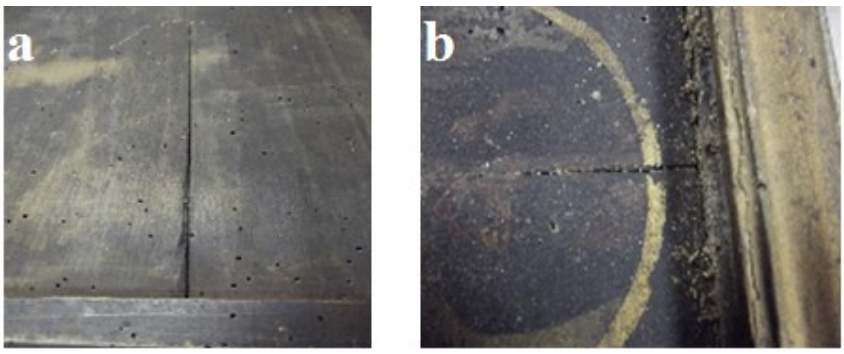

Fig. 3. The Grieving Mother from Rohia nr.113:distance between the boards of the panel:a – back, b – front;

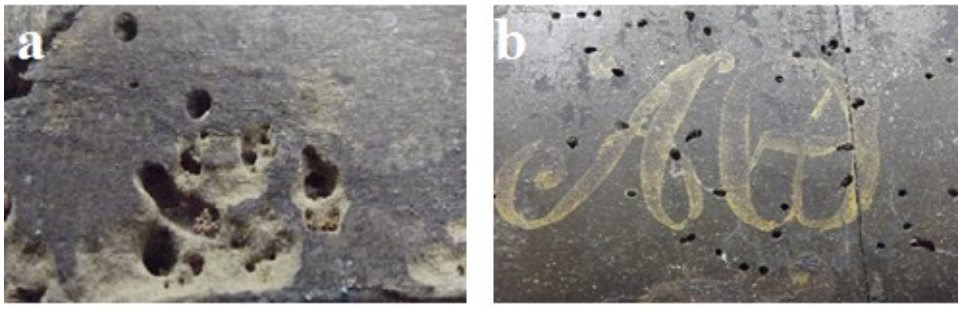

Fig. 4. The Grieving Mother from Rohia: a – xylophagous atac on the back of the icon nr. 112; b - xylophagous atac on the back of the icon nr. 113;

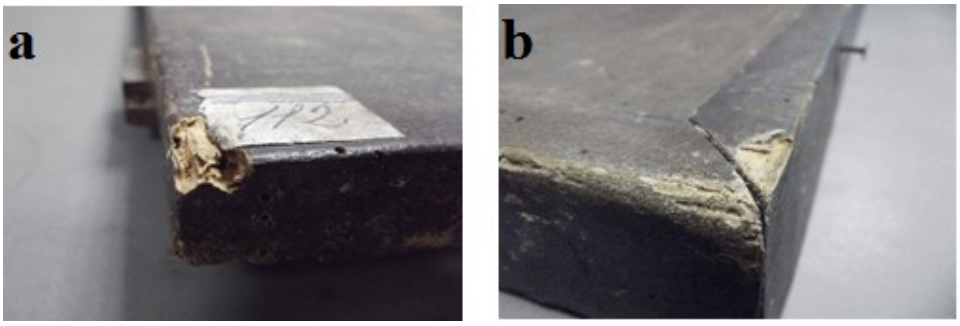

Fig. 5. The Grieving Mother from Rohia: a - support missing on the icon nr. 112; b - support missing on the icon nr.113

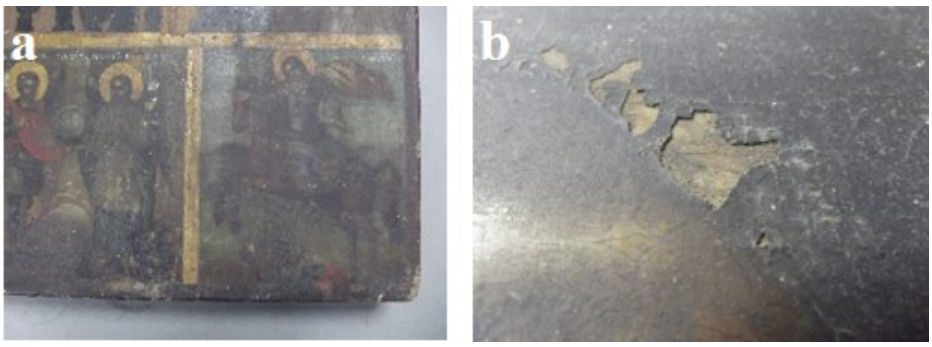

Fig. 6. The Grieving Mother from Rohia: a – dirt on the icon nr. 112; b - dirt on the icon nr. 113

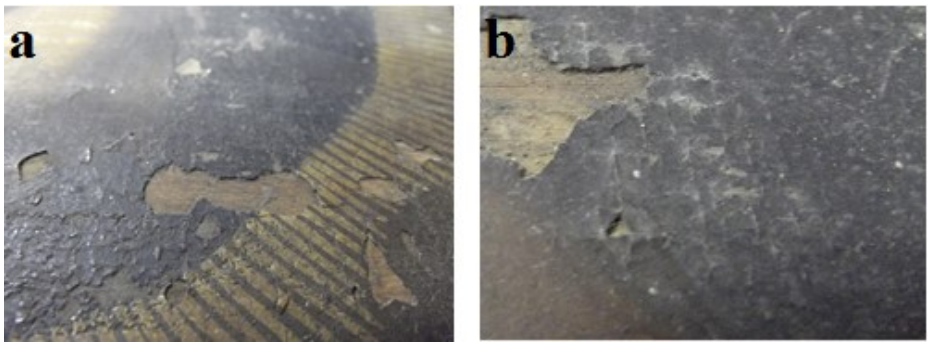

Fig. 7. The Grieving Mother from Rohia: a - cracks of the painting layer on the icon nr. 112; b - cracks of the painting layer on the icon nr. 113

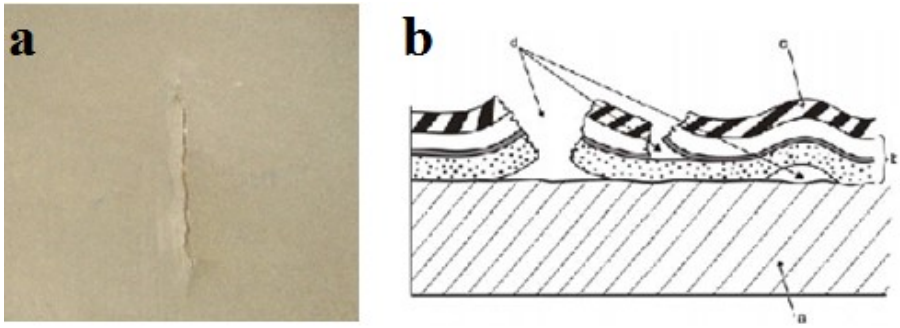

Fig. 8. The Grieving Mother from Rohia: a - detachments on the icon nr. 113b - stratigraphic structural drawing(a – wooden support, b – painting layer, c – dirt, d – detachments;)

2. Experimental part

Five samples from each painting layer of the two icons were taken as shown in the figures 9 a and b.

Fig. 9. Areas from where the samples were taken: a- Icon number 112 a) - face; b - halo; c - background; d - cloak; e – lower scene border; b) - Icon number 113 a - face; b - halo; c - background; d - cloak; e – lower scene border

The following instruments were used in analysis: CARL ZEISS AXIO IMAGER A1m microscope, with an attached AXIOCAM camera, the samples being enhanced between 50X and 500X.in order to identify chemical elements, the samples were analyzed with an electronic microscope, model VEGS II LSH, made by TESCAN, in Check Republic, coupled with an QUANTAX QX2 X-ray spectroscope, made by BRULER/PROENTEC from Germany. The Micro-FTIR spectrums were recorded with a FT-IR spectroscope coupled with a Hyperion 1000 microscope, both from Brüker Optic Equipment, Germania [11-13].

Based on the optical microscope analysis of the 10 samples taken from the two samples it was determined that the colors used to create the background and the cloaks are similar: a combination of blue, black and green for cloaks and green, ochre, umber and black for the background (fig. 11. c-h). The face is made in both cases with a mixture of white, ochre and green and black in shadow (fig. 11. a-b). The last two samples analyzed were those taken from the lower scenes borders.

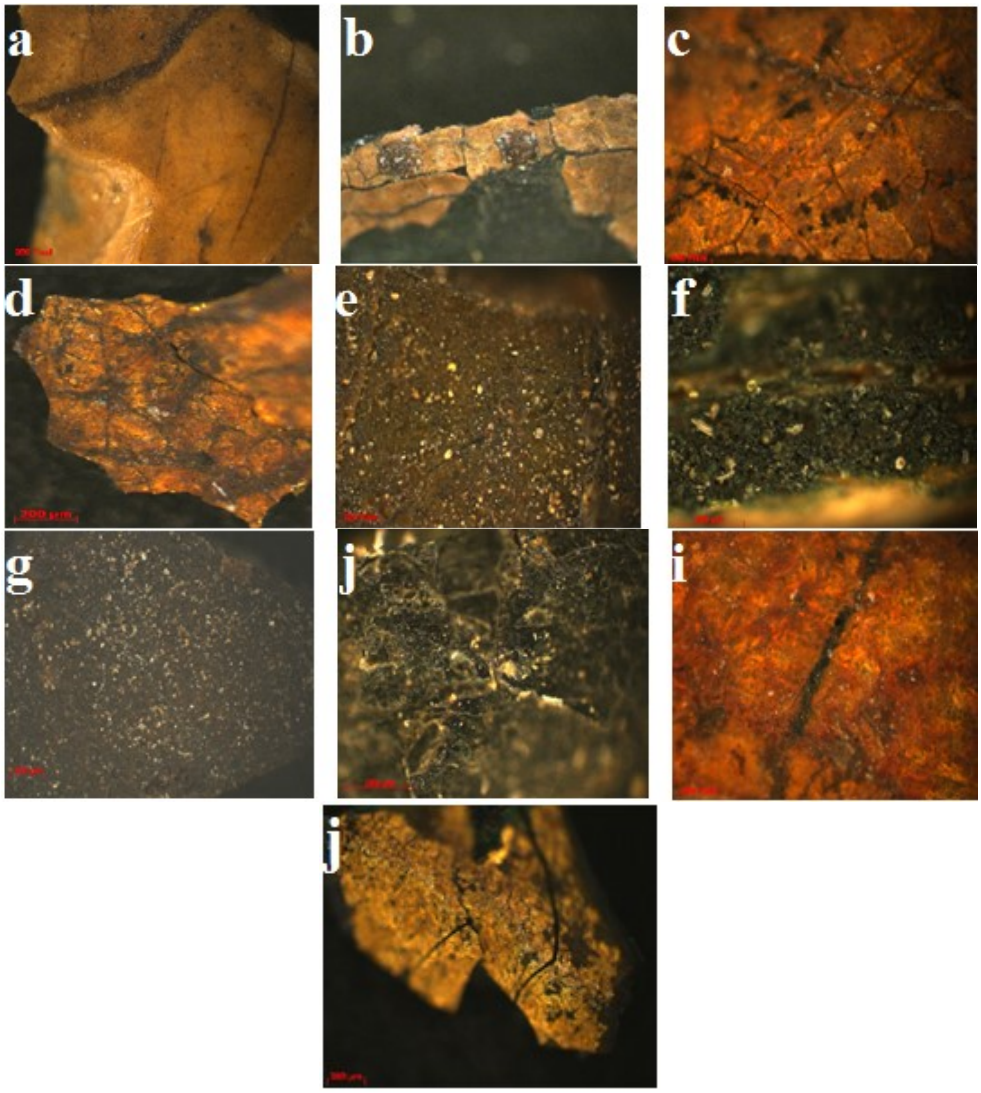

Fig. 11. Images obtained with the OM for the samples taken from different areas of the two icons: a – face from the icon nr. 112; b – face from the icon nr. 113; c -halo from the icon nr. 112; d - halo from the icon nr. 113; e – background from the icon nr. 112; f – background from the icon nr. 113; g –cloak from the icon nr. 112; h – cloak from the icon nr. 113; i - borders from the icon nr. 112; j - borders from the icon nr. 113;

The sample taken from from the icon number 112 shows a metallic yellow leaf (fig. 11i). The sample taken from the border of the icon number 113 presents a yellow metallic pigment (fig. 11j). All samples show significant traces of clogged dirt and cracked varnish.

The SEM-EDX analysis was done on the same 10 sample taken from the two painting layers (fig. 12-18). One of the first conclusions was the lack of ground and canvas, which was a decisive factor in the evolution of the deteriorations and the degradations of the two icons. It was also established that the green pigment used in the painting of the backgrounds is earth green $K[(Al,FeIII),(FeII,Mg)](AlSi_3,Si_4)O_{10}(OH)_2$, combined with carbon black, ocher (FeO) and burned or natural umber $Fe_2O_3 \cdot H_2O + MnO_2 \cdot n\ H_2O + Al_2O_3$ (fig.14-15). The cloaks were done with a mixture of ultramarine natural blue $Na_{8\text{-}10}Al_6Si_6O_{24}S_{2\text{-}4}$, mixed with carbon black and earth green (fig. 12-13)[6]. The face of The Virgin Mary on both icons was done with lead white ($2PbCO_3 \cdot Pb(OH)_2$) and yellow iron oxide ($Fe_2O_3 \cdot 4H_2O$) or mars yellow (fig. 16-17). The SEM-EDX analysis of the sample taken from the halo of the icon number 112 revealed that the metallic leaf used is silver, not gold leaf as originally believed (Fig. 18). In the case of the icon number 113, the yellow metallic pigment used was based on S, Cr şi Pb (realgar or orpigment, mixed with other earth colors) (Fig. 19) [14-16].

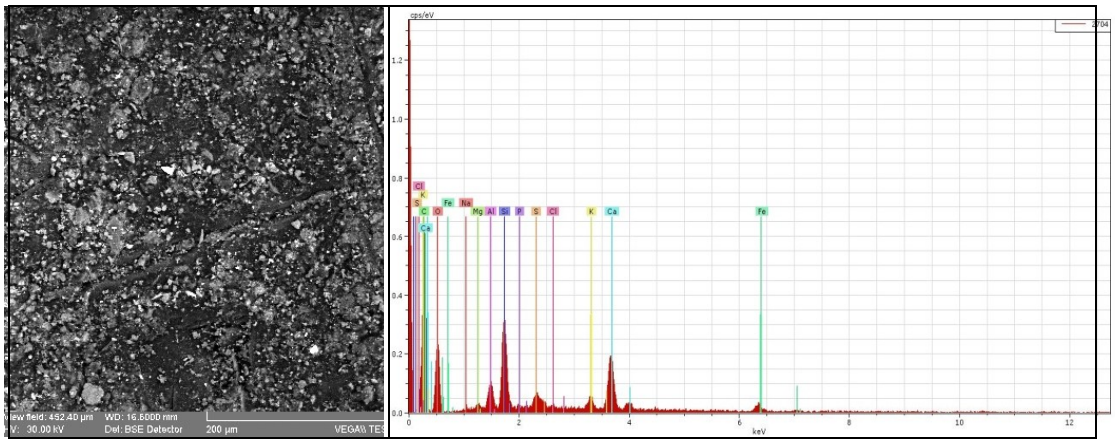

Fig. 12. SEM microphotography, BSE, 500X, EDX spectrum of the sample taken from the cloak of the icon nr. 112

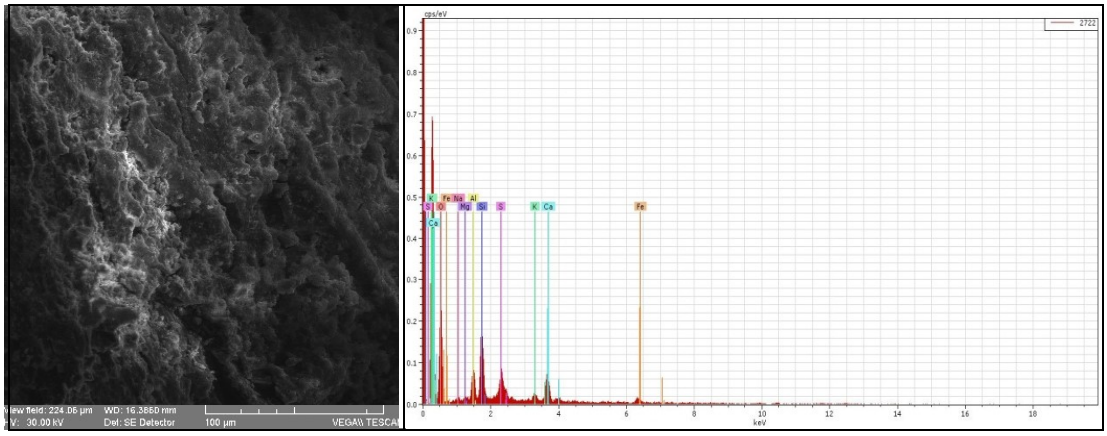

Fig. 13. SEM microphotography, SE, 1000X, EDX spectrum of the sample taken from the cloak of the icon nr. 113

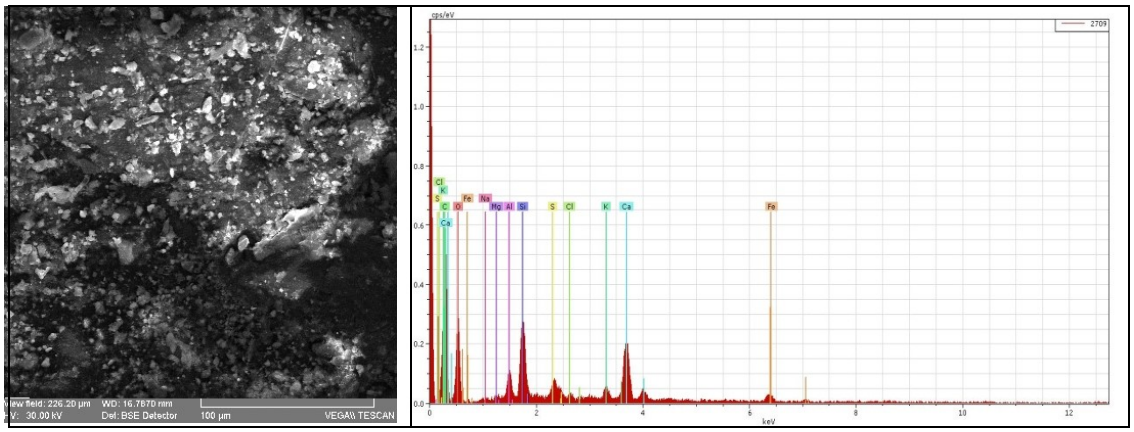

Fig. 14. SEM microphotography, BSE, 1000X, EDX spectrum of the sample taken from the background of the icon nr. 112

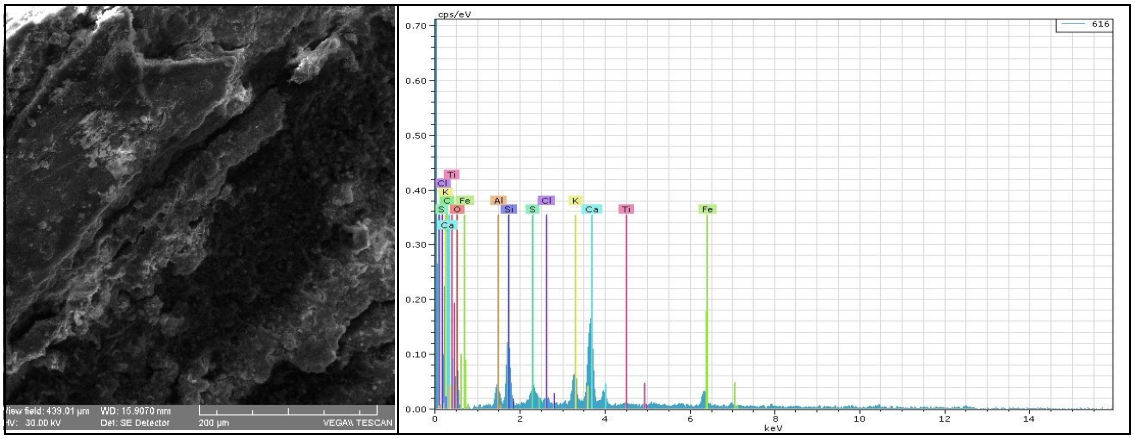

Fig. 15. SEM microphotography, SE, 500X, EDX spectrum of the sample taken from the background of the icon nr. 113

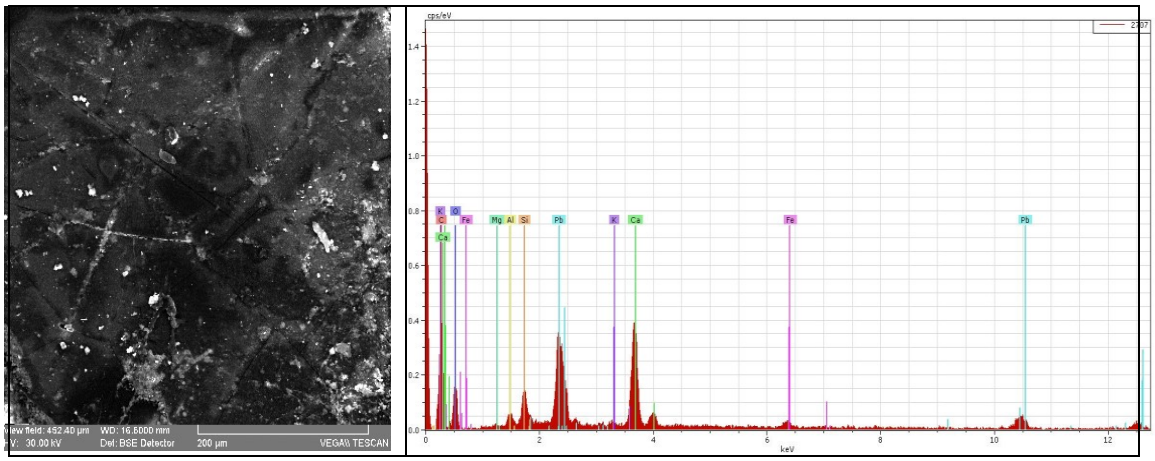

Fig. 16. SEM microphotography, BSE, 500X, EDX spectrum of the sample takenfrom the face of the icon nr. 112

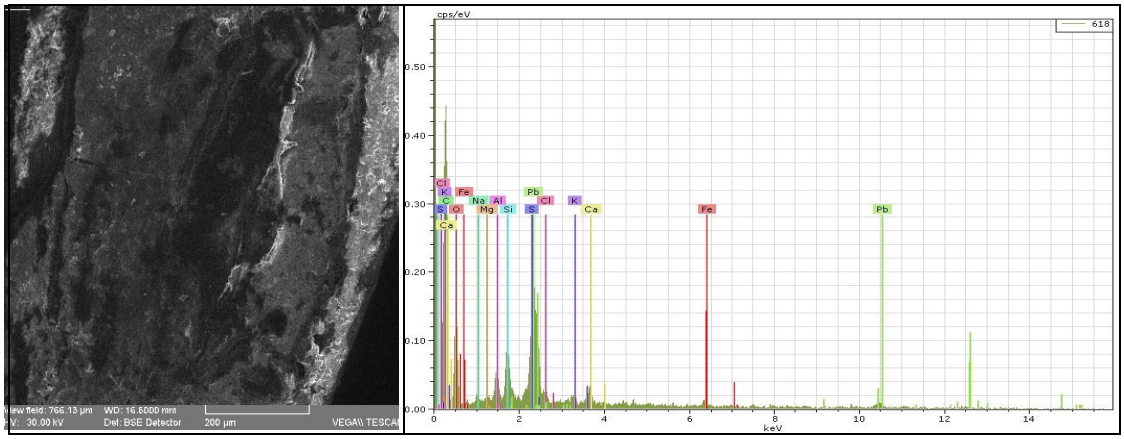

Fig. 17. SEM microphotography, BSE, 300X, EDX spectrum of the sample taken from the face of the icon nr. 113

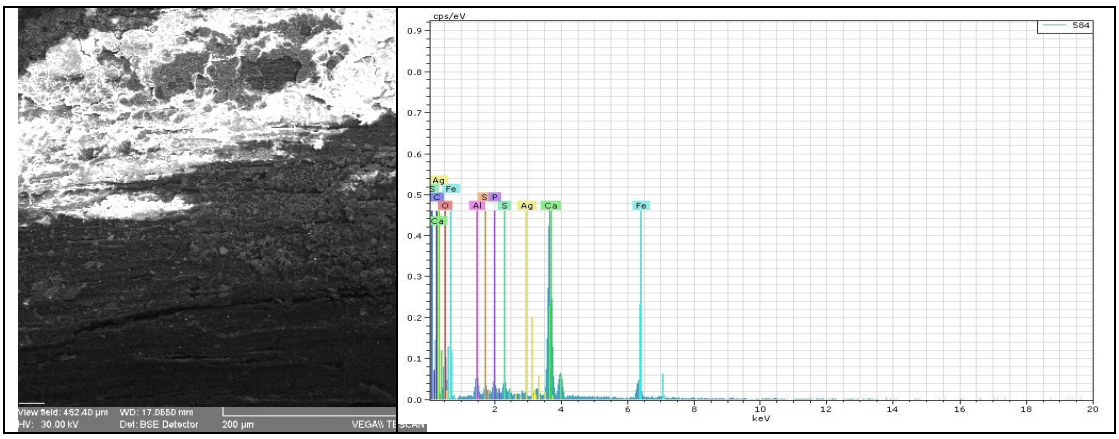

Fig. 18. SEM microphotography, BSE, 1500X, EDX spectrum of the sample taken from the halo of the icon nr. 112

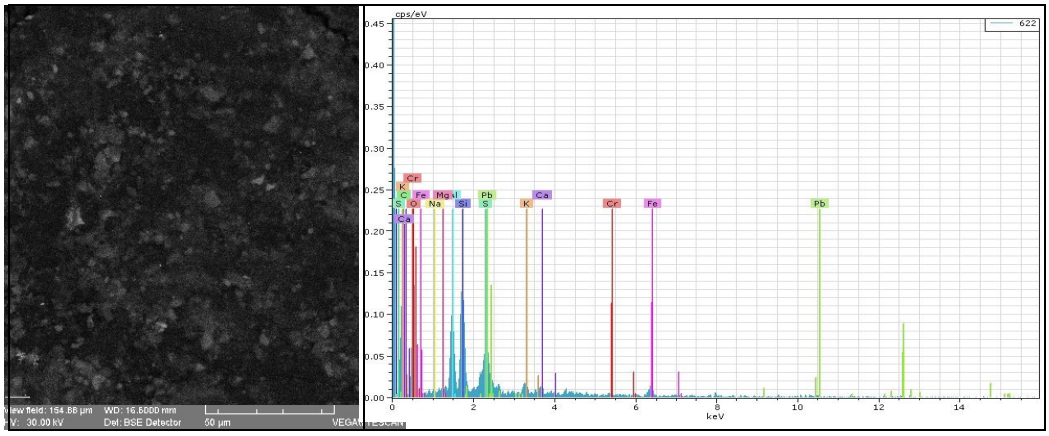

Fig. 19. SEM microphotography, BSE, 500X, EDX spectrum of the sample taken from the halo of the icon nr. 113

Tab. 1. SEM-EDX results

Nr.	Sample	Chemical elements identified	Concentration (wt.-%)	Determined pigments
1	Cloak of the icon number 112	Carbon	16.38881	ultramarine natural blue $Na_{8-10}Al_6Si_6O_{24}S_{2-4}$, mixed with carbon black and earth green, $K[(Al,FeIII),(FeII,Mg)](AlSi_3,Si_4)O_{10}(OH)_2$.
		Silicon	6.172971	
		Calcium	3.941729	
		Aluminium	2.267281	
		Sulfur	1.386985	
		Iron	1.512083	
		Potassium	1.228655	
		Chlorine	0.230147	
		Magnesium	0.681442	
		Sodium	0.642462	
		Phosphorus	0.252832	
		Oxygen	65.2926	
2	Cloak of the icon number 113	Carbon	14.12818	ultramarine natural blue $Na_{8-10}Al_6Si_6O_{24}S_{2-4}$, mixed with carbon black and earth green, $K[(Al,FeIII),(FeII,Mg)](AlSi_3,Si_4)O_{10}(OH)_2$.
		Silicon	6.149608	
		Calcium	2.667325	
		Sulfur	3.429675	
		Aluminium	3.294889	
		Iron	1.285284	
		Potassium	1.279955	
		Magnesium	0.828494	
		Sodium	1.508789	

		Oxygen	65.42581	
3	Background of the icon number 112	Carbon	15.0315	earth green $K[(Al,FeIII),(FeII,Mg)](AlSi_3,Si_4)O_{10}(OH)_2$, carbon black, ocher (FeO), burned or natural umber $Fe_2O_3 \cdot H_2O$ + $MnO_2 \cdot n\ H_2O$+ Al_2O_3
		Silicon	5.320449	
		Calcium	4.118289	
		Aluminium	2.137188	
		Sulfur	1.470609	
		Iron	1.172684	
		Potassium	0.753333	
		Magnesium	0.52451	
		Sodium	0.650922	
		Chlorine	0.261094	
		Oxygen	68.55742	
4	Background of the icon number 113	Carbon	19.01557	earth green $K[(Al,FeIII),(FeII,Mg)](AlSi_3,Si_4)O_{10}(OH)_2$, carbon black, ocher (FeO), burned or natural umber $Fe_2O_3 \cdot H_2O$ + $MnO_2 \cdot n\ H_2O$+ Al_2O_3
		Silicon	2.560286	
		Calcium	3.81289	
		Potassium	1.923999	
		Aluminium	0.952073	
		Sulfur	0.742888	
		Chlorine	0.174678	
		Titanium	0.393397	
		Iron	1.316699	
		Oxygen	69.1059	
5	Face of the icon number 112	Carbon	12.18437	lead white ($2PbCO_3 \cdot Pb(OH)_2$) and yellow iron oxide ($Fe_2O_3 \cdot 4H_2O$)
		Calcium	10.09271	
		Iron	1.549817	
		Aluminium	1.081189	
		Lead	22.09014	
		Silicon	2.510692	
		Magnesium	0.308795	
		Potassium	1.535387	
		Oxygen	69.08678	
			12.18437	
6	Face of the icon number 113	Carbon	10.13674	lead white ($2PbCO_3 \cdot Pb(OH)_2$) and yellow iron oxide ($Fe_2O_3 \cdot 4H_2O$)
		Calcium	8.55483	
		Iron	1.89711	
		Lead	21.52378	
		Aluminium	0.95278	
		Magnesium	0.48537	
		Silicon	2.28903	
		Potassium	1.57688	
		Oxygen	52.58347	

7	Halo of the icon number 112	Calcium	17.72147	metallic silver leaf, covered with colophon
		Carbon	12.01592	
		Iron	4.579725	
		Aluminium	1.703742	
		Silver	1.18262	
		Silicon	0.490081	
		Sulfur	0.753321	
		Phosphorus	0.71379	
		Oxygen	74.078	
8	Halo of the icon number 113	Carbon	11.3623	yellow metallic pigment based on S, Cr şi Pb (realgar or orpigment) mixed with other earth colors.
		Silicon	10.86487	
		Aluminium	8.959683	
		Iron	2.591668	
		Sodium	1.848374	
		Potassium	1.477127	
		Sulfur	3.961862	
		Calcium	1.075373	
		Magnesium	1.474293	
		Lead	18.87234	
		Chromium	0.887938	
		Oxygen	36.62217	

The results obtained after OM and SEM-EDX were confirmed through micro-FTIR analysis, specific peaks being identifyed for several pigments and material used, as followed:

✓ natural ultramarin blue pigment 628, 655, 699 and 735cm^{-1} in the micro FTIR spectrum of the icon number 112 (fig. 20a) and 639, 694 and 724cm^{-1}, in the spectrum of the icon number 113 (fig. 20b).

✓ For carbonates (calcium and lead based) 795, 829 and 886cm^{-1} (fig. 20a), 816 and 883cm^{-1} (fig. 20b), 849 and 887cm^{-1} (fig. 21a), 812 and 845cm^{-1} (fig. 22a), 801 and 868cm^{-1} (fig. 22b).

✓ Earth green was identified by peaks specific to alumino silicates: 1473 and 1581cm^{-1} (fig. 20a), 1464, 1523 and 1599cm^{-1} (fig. 20b), 1469 and 1599cm^{-1} (fig. 21a), 1467cm^{-1} (fig. 21b), 1468 and 1595cm^{-1} (fig. 22a), 1467 and 1570cm^{-1} (fig. 22b).

✓ The carbon black was identified by used peaks specific for tar: 1056cm^{-1} (fig. 20a), 925 and 1060cm^{-1} (fig. 20b), 921 and 1052cm^{-1} (fig. 21a), 925cm^{-1} (fig. 22a), 936 and 1015cm^{-1}(fig. 22b). The presence of carbon black in the sample from the face of the icon number 112 is explained by the fact that the sample was taken from the shadow.

✓ For amidic group from peptides, the amino group and the carbonic group from amino acids: 1581 and1680cm^{-1} (fig. 20a), 1523 and 1737cm^{-1} (fig. 20b), 1599, 1678, 1741cm^{-1} (fig. 21a), 1678 and 1739cm^{-1} (fig. 21b), 1595 and 1724cm^{-1} (fig. 22a), 1644 and 1736cm^{-1} (fig. 22b).

The colophon, with resin acids as a main component, the identification was done by the peaks specific for carboxylic, aldehidic and hidroxilic groups, as followed: in figure 20a, 1056 and 2012cm^{-1}, in figure 20b, 1060 and 2093cm^{-1}, in figure 21a, 2131cm^{-1}, in figure 21b, 1052 and 2093cm^{-1}, in figure 22a, 2090cm^{-1} and in figure 22b, 1061 and 2099cm^{-1}.

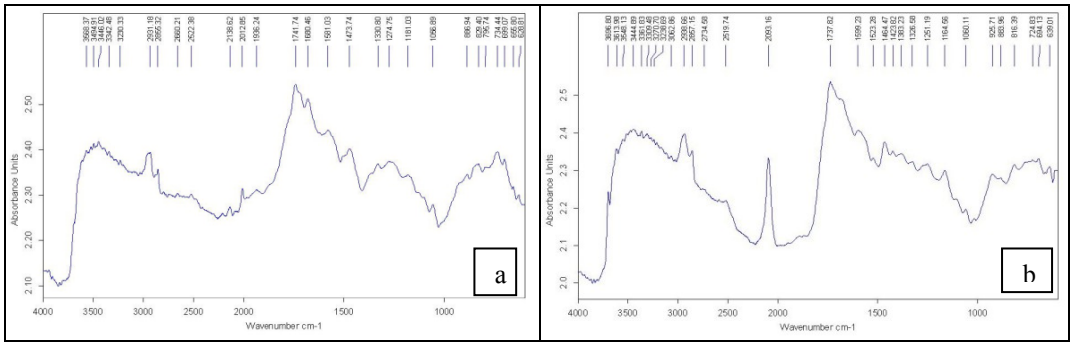

Fig. 20. Cloak micro-FTIR spectrum: a) icon number 112; b) icon number 113

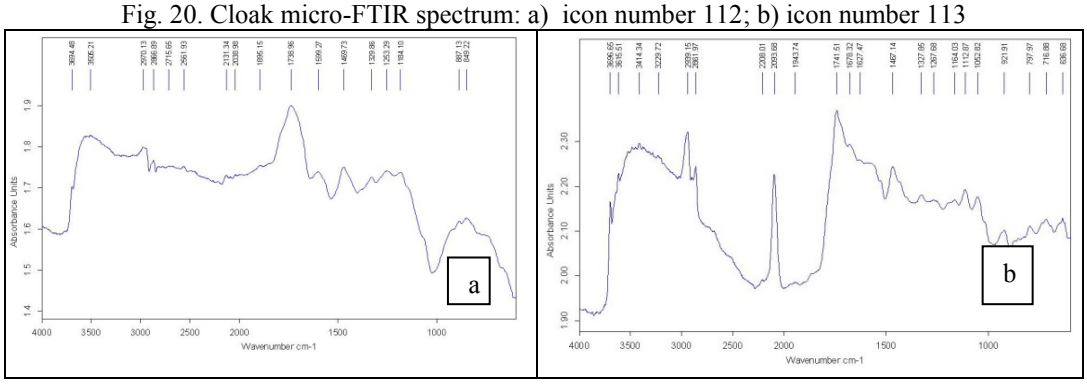

Fig. 21. Face micro-FTIR spectrum: a) icon number 112; b) icon number 113

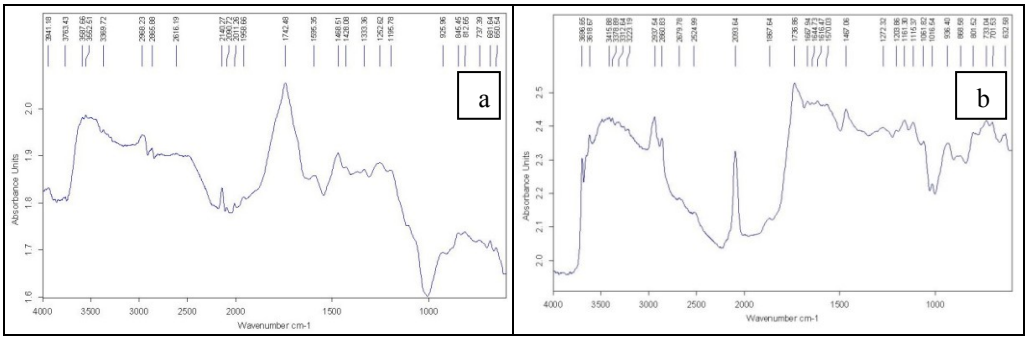

Fig. 22. Background micro-FTIR spectrum:a) icon number 112; b) icon number 113

Tab. 2. Micro-FTIR results

Nr.	Identified pigments	Peaks in sample from the cloak of icon number 112 (cm^{-1})	Peaks in sample from the cloak of icon number 113 (cm^{-1})	Peaks in sample from the face of the icon number 112 (cm^{-1})	Peaks in sample from the face of the icon number 113 (cm^{-1})	Peaks in sample from the background of the icon number 112 (cm^{-1})	Peaks in sample from the background of the icon number 113 (cm^{-1})
1	Natural ultramarin blue pigment	628, 655, 699, 735	639, 694 724	-	-	-	-
2	Carbonates (calcium and lead based)	795, 829, 886	816, 883	849, 887	-	812, 845	801, 868
3	Alumino silicates - earth green	1473, 1581	1464, 1523, 1599	1469, 1599	1467	1468, 1595	1570
4	Carbon black	1056	925, 1060	921, 1052	-	925	936, 1015
5	Amidic group from peptides, the amino group and the carbonic group from amino acids	1581, 1680	1523, 1737	1599, 1678, 1741	1678, 1739	1595, 1724	1644, 1736
6	Colophon, with resin acids as a main component	1056, 2012	1060, 2093	2131	1052, 2093	2090	1061, 2099

3. Stages of the restoration processes

The first stage of the restoration process is the consolidation of the painting layers in order to prevent the loss of other painting pieces already detached. The consolidation was done by fixing the painting layer with fish glue (8%) and japanese paper.

The stopping of the xylophagous attack was done by encapsulating the two icons in a polyethylene bag for a period of 14 days. In the bag the value of oxygen

was reduced below 0.1% by replacing it with nitrogen (fig. 23-24). The nitrogen atmosphere in the bag was done with the help of a hose and adapter coupling. The operation of replacing the oxygen with nitrogen was repeated four times to ensure the required level of oxygen. After that the bag will be totally sealed and opened again at the end of those 14 days.

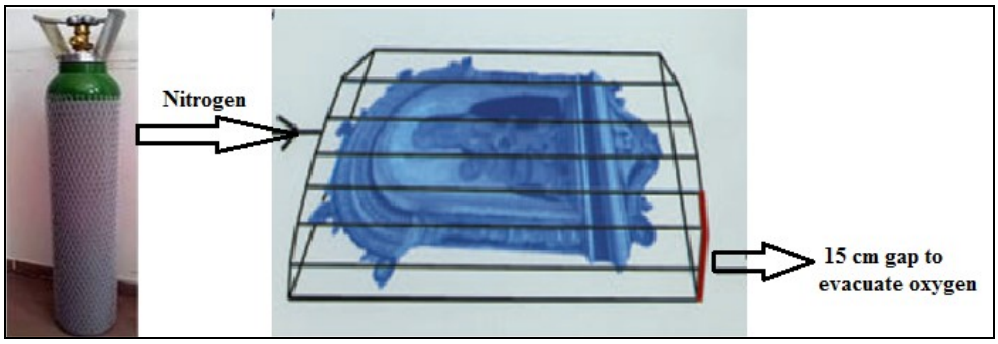

Fig. 23. The scheme of the criptoclimate

Fig. 24. Icon number 112 inside the criptoclimate

The next stage was to consolidate the two wooden panels with a mixture of colophony and natural bee wax, on a 1:1 ratio. The consolidation gave back the structural integrity that the two panels losed it as a consequence of the xylophagous attack (fig. 25) [17-19].

Fig. 25. Consolidating the wood support wiwax and colophony

Fig. 26. Cleaning test of the icon number 112

After that the painting layers were cleaned with a solution of ethylic alcohol and distilled water (1:1). This solution had the best results in the cleaning test executed as shown in the figure 26. After the clogged dirt was cleaned and the aged varnish was removed, the gaps of the two icons were also cleaned and then filled with a mixture of animal glue (8%) and charcoal. The filling will be applied in thin layers, with a window of a minimum 12 hours between applications, in order to ensure a proper exsiccation of the filled gaps. The filled gaps were sanded off and then reintegrated using *tratteggio* technique. The information obtained about the pigments used by the painters was taken into consideration in choosing the colors used for reintegration. Pigments with similar physical properties with those of the original colors were used.

After the gaps were reintegrated, the two icons were revarnished in order to ensure o proper protection against the future processes of deterioration and degradation that will affect the painting layers.

Conclusions

This study presented the stages of the restoration process of two XIX-th century icons, which are part of the cultural heritage of"Sfinții Mihail și Gavriil" from Moscu village, Galați. The icons suffer from a series of evaluative deteriorations and degradations processes, due to the improper storage environment. In order to reintegrate the two icons in the religious circuit, a restoration protocol was established and followed. A series of tests were employed, in order to determine the materials used by the painters, and then the established stages of the restoration protocol were followed: stopping the xylophagous attack by anaerobic treatment, consolidating the two wood panels and the painting layers, removing the clogged dirt and the degraded varnish, filling and sanding off the gaps, reintegration in *tratteggio* and varnishing the icons. For the chromatic

reintegration pigments with similar properties like the properties of the original colors were used. The study present the stages of the restoration process of the two XIX-th icons, that were affected by being kept in an improper environment from a climatic point of view, and the results of the analysis done in order to collect information. MO, SEM-EDX and micro-FTIR were done on five samples collected from each icon. The following pigments were identified: natural ultramarine blue, earth green, carbon black, yellow iron oxide, lead white, burned and unburned umber. It was also established that colophon was used to protect the painting layer. In both cases, the gold leaf usually used in byzantine painting was replaced with silver leaf covered with varnish (icon number 112) or with yellow metallic pigments (realgar or orpigment). The restoration process that started after the analyses had the following stages: : consolidation of the painting layer (fish glue 8% and japanese paper), stopping the xylophagous attack (encapsulation with nitrogen), consolidation of the wood supports (colophon and wax, 1:1), cleaning the painting layer (ethylic alcohol and distilled water, 1:1), filling the gaps and reintegrating the fillings in *tratteggio*, all followed by the process of varnishing the two icons.

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GEOSTATISTICAL APPROACH TO FIND 'HOTSPOTS' WHERE BIODIVERSITY IS AT RISK IN A TRANSITION COUNTRY

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Key-words: land cover and use changes; CORINE; transitional dynamics; kriging; desertification

Abstract. Global change' is a relatively recent concept, related to the energy - land use - climate change nexus, and designated to include all changes produced by the human species and the consequences of its activities over natural ecological complexes and biodiversity. The joint effects of these drivers of change are particularly relevant to understanding the changes of biodiversity. This study overlaps results of previous studies developed in Romania to find, explain and predict potential threats on biodiversity, including the effects of very high temperatures and low precipitations, urban sprawl and deforestation in order to identify 'hotspots' of high risk for the loss of biodiversity using geostatistical tools. The results found two hotspots, one in the center and the other one in the south, and show that the area affected by three factors simultaneously represents 0.2% of the national territory, while paired effects cover 4% of it. The methodological advantage of this approach is its capacity to pinpoint hotspots with practical relevance. Nevertheless, its generalizing character impairs its use at the local scale..

Introduction

The spatial sprawl of human society is due to the growth of population and increasing human needs. Possible outcomes include: (1) substitution, simplification and fragmentation of natural systems, resulting into restricting their connectivity; (2) increased heterogeneity and specialization of man-dominated systems, increasing mass and energy flows and dumping pollutants in the natural ones; (3) linearization of biogeochemical cycles, resulting into the concentration of mineral substances in waste, and exhaustion of natural resources; (4) increasing

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interdependence of subsystems expands their scale to the regional and global one (Vădineanu, 1998; Jongman, 2003). 'Global change' is a new concept used to refer all man-driven changes of the whole ecosphere: climate change, land use alterations, and change of energy flows (Dale *et al*., 2011), including their close inter-relationships (Dale, 1997; You, 2001; Dale *et al*., 2009; Petrişor *et al*., 2012c).

Previous studies showed the importance of energy, as human activities use energy from natural systems, creating additional trophy levels, such as techno-trophy (use of energy in industry) or noo-trophy (use in support activities, such as research or management), connecting man-dominated systems to natural ones in order to find the energy and resources needed for their functioning (Ianoş, 2000b; Petrişor and Sârbu, 2010). The concept of 'primary eco-energy' ties energy to land use and means the initial energy of a system before conscious man intervention over its structure (Ianoş, 2000b). A study carried out in Sărăţel river basin underlined tight links between land cover and use changes and consumption of primary eco-energy (Ianoş *et al*., 2011). Jensen (2000) shows that 'land cover' means what can be found on the ground from a biophysical perspective, and 'land use' shows its usage by humans. However, the second is valid for man-dominated systems; in natural systems, 'land use' shows their more detailed classification (Petrişor *et al*., 2010).

Changes of land cover and use can be investigated using satellite data (Zhao *et al*., 2003). The European Union uses CORINE classification of land cover and use, with three levels; the first one reflects land cover and the second land use, in more or less detail (de Lima, 2005). Since CORINE data cover the whole European continent, only three data sets are available from 1990, 2000, and 2006. Due to their spatial and temporal extent, CORINE data are useful to analyze long term changes of large territories (Petrişor *et al*., 2010; Petrişor, 2012b).

The effects of climate change, land use and energy on biodiversity were investigated by numerous studies. Climate change decreases overall diversity through effects on individuals, species and ecosystems (Dukes and Mooney, 1999; Thomas *et al*., 2004; Parmesan, 2006), but can favor invasive species (Penuelas and Filella, 2001; Penuelas *et al*., 2002; Patz *et al*., 2008). The effects of altered land use differ with respect to their nature; deforestation and urbanization result into the loss of biodiversity (Jongman, 2003; Petrişor *et al*., 2010; Chelaru and Apostol, 2012), although urbanization can favor invasive species (Wang *et al*., 2011). The two can alter the energy balance, and have synergetic effects (Dale, 1997; Dale *et al*. 20011; Petrişor *et al*., 2012c). Conservationists aim to identify 'biodiversity hotspots' where the action of more stressors overlaps, and are a priority for conservation (Gillespie *et al*., 2012). Therefore, it is important to analyze connections spatially (Matin *et al*., 2012).

The connections between man-driven environmental changes and underlying causes, between the different pressures can be underlined if the analysis of spatial data (*e.g.*, land cover and use data) is carried out in conjunction with statistical approaches (Benning *et al.*, 2002). Previous studies carried out at in Romania looked at the influence of climate change and land use alterations on natural ecosystems. Climate change studies have analyzed the influence of increasing temperatures (Petrişor, 2010) and decreasing precipitations (Petrişor, 2011) on biodiversity and natural protected areas in Romania and their relationship with land cover and use changes occurring between 1990-2006 (Petrişor, 2012c). Studies looking at land cover and use changes were carried out over the entire territory for all types of changes (Petrişor, 2012a), with a special focus on urbanization (Petrişor *et al.*, 2010; Petrişor, 2012b), or over particular areas, in relationship with the distribution of primary eco-energy (Ianoş *et al.*, 2011). The last two studies identified 'hotspots' of intense transitional dynamics such as urbanization, deforestation, afforestation or reforestation, agricultural abandon or development, and discussed them in relationship with the socio-economic changes that occurred in Romania or particular areas investigated during the period covered by data, since these forces were the most important drivers of change (Petrişor *et al.*, 2010).

This study aims to overlap, using geostatistical approaches, spatial data on the pressure of high temperatures, low precipitations, urbanization and deforestation to identify the 'hotspots' most likely to indicate the loss of biodiversity, considered areas at highest risk, starting from the hypothesis according to which the most important driver of change in a transition country is the unwise management of land, resulting into environmental impacts aggravated by the consequences of climate change.

1. Data and methods

CORINE land cover and use changes data are freely offered by the European Environment Agency (EEA). The two data sets reflect changes occurred between 1990 and 2000 (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-1990) and 2000-2006 (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000). Climate change data are freely available from Berkeley University in DIVA-GIS format (Hijmans *et al.*, 2001) at http://biogeo.berkeley.edu/worldclim/diva/diva_worldclim_2-5m.zip (current), and http://biogeo.berkeley.edu/worldclim/diva/diva_wc_ccm3_2-5m.zip (2100 predictions). Current data are a result of WorldClim project (Hijmans *et al.*, 2003); 2100 predictions are based on double CO_2 concentrations and the CCM3 model (Govindasamy *et al.*, 2005).

CORINE data are in a GIS format. Climate data are in a specific format, converted to GIS files. Converted DIVA-GIS data is vector obtained by summing

up 2.5 min × 2.5 min raster cells. Spatial interpolation used the X-Tools extension of ArcView GIS 3.X was used to find the geometric center of each polygon, keeping the polygon attributes: area of parcels with changed land cover and use and difference between predicted and current temperatures or precipitations.

Two subsets were derived: a subset showing potential effects of climate change, including largest increase of temperatures and decrease of precipitations, and a subset with land cover and use changes attributable to urbanization and deforestations. The latest were chosen due to their importance underlined by previous studies (Ianoş *et al*., 2011; Petrişor, 2012a; Vartolomei, 2012). The largest increase of temperatures and decrease of precipitations were found looking at the histograms showing the statistical distribution of differences, and choosing intervals comparable in size for temperatures and precipitations and not exceeding 10% (Petrişor, 2011). Land cover changes attributable to urbanization included changes of other CORINE level 1 classes into 'artificial' and land use changes within the 'artificial' class indicating urban development (Petrişor *et al*., 2010; Petrişor, 2012b). Deforestation was defined by land cover changes of previous forest areas into other classes, not due to urbanization, and land use classes indicating deforestation (Petrişor, 2012c).

In order to analyze the joint action of stressors, the overlapping areas were computed. First, there is no area where all factors (high temperatures, low precipitations, urbanization and deforestation) occur together. However, particular joint action of two or three factors might be of interest; if high temperatures and low precipitations occur simultaneously, the area is at risk for desertification (You, 2001). The same is valid if deforestation acts together with high temperatures and/or low precipitations. The joint action of urbanization and high temperatures and/or low precipitations results into possible heat islands (Rizwan *et al*., 2008; Cheval and Dumitrescu, 2009; Cheval *et al*., 2009). However, instead of discussing all possible combinations, the study looked at the risk classified as 'high' if three factors act together, 'moderate' if only two factors join their effects, and low if a single factor acts.

3. Results and discussion

The map displayed in Fig. 1 shows the joint action of factors with potential impact on biodiversity. The risk for loss of biodiversity is considered 'high' if three stressors act jointly, 'moderate' if only two act together and 'low' if there is only one factor.

The figure shows that most factors resulting into the loss of biodiversity cover the mountain region; these areas are highly sensitive to climate changes (Keiler *et al*., 2010), particularly when subjected to deforestation (Knorn *et al*., 2012). European alpine regions are very important threatened systems with high

biodiversity (Borsdorf and Braun, 2008) and high levels of primary eco-energy (Ianoş, 2000b).

These results are confirmed by the findings of previous studies, showing a central hotspot with the highest risk for the loss of biodiversity, due to the joint action of three stressors in small areas and of two stressors in an extended region surrounding it. This area appears to be affected by all types of stressors: urbanization, deforestations, high temperatures and low precipitations. In addition, the curvature of the Carpathians is the epicenter of most Romanian earthquakes (Boştenaru Dan, 2005; Georgescu and Pomonis, 2011). According to previous findings, primary eco-energies are present at high levels in the area (Ianoş, 2000b; Ianoş *et al*., 2011), indicating that anthropic pressures did not exist in the past. The neighboring region, situated in its western part is characterized by increased socio-economic underdevelopment during the economic crisis (Muntean *et al*., 2010). This is probably the most relevant 'hotspot' where biodiversity is at risk. Previous studies show that some effects have already been documented; temperature and precipitation changes favored its colonization by alien species (Duduman *et al*., 2011; Sirbu and Oprea, 2011).

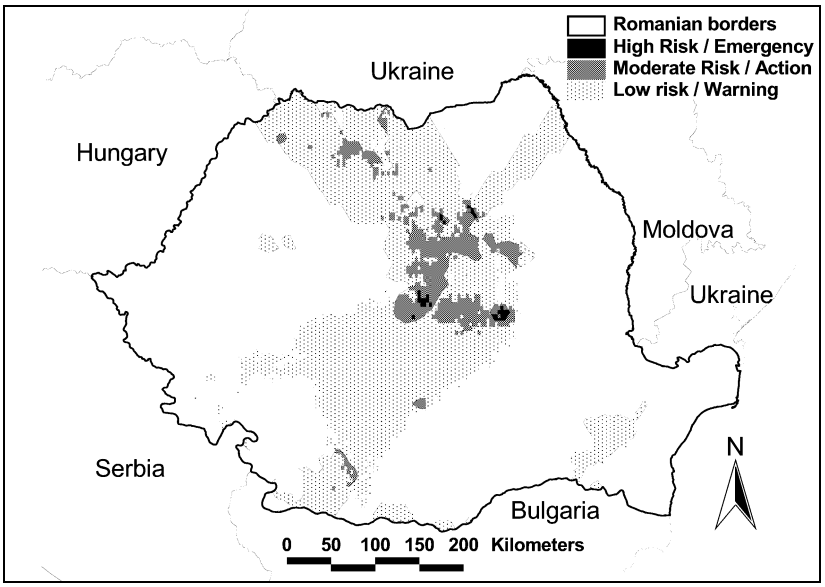

Fig. 1. Showing the joint action of factors resulting into the loss of biodiversity in Romania. The shading indicates the risk, considered 'high' (calling for urgent action) if three factors combine their action, 'moderate' (involving medium-term actions) if only two factors act jointly and 'low' (reclaiming long-term strategies) if only one factor is present. The map disregards the nature of stressors.

In addition to the mountain regions, deforestations are likely to affect ecosystems situated in the Danube floodplain (southern and eastern Romania, close to the Bulgarian border), also prone to climate changes (Ionac and Grigore, 2012; Prăvălie, 2013). The massif deforestations in southern Romania, in conjunction with predicted growth of temperatures, are likely to be the cause of the desertification of this area at moderate risk. Other research confirmed changes of the composition of plant and animal communities, suggesting a desertification process (Marinică and Chimişliu, 2008; Vlăduţ, 2010; Meiţă *et al*., 2011; Petrişor *et al*., 2011; Corneanu *et al*., 2012; Rosu and Oişte, 2013). Additional pressures are present in the area; the impacts of mining are still present (Braghină *et al*., 2010, 2011; Vartolomei *et al*., 2013), even though urban restructuring after 1989 resulted into the loss of the function of former industrial cities due to the decline of mining activities (Ianoş, 2000a).

Other areas at risk expand to the north, covering the mountain region. In a practical perspective, the 'low' risk constitutes a warning, calling for long-term strategies aimed to diminish individual pressures and mitigate their effects; 'moderate risk' calls for medium-term strategies resulting into concrete actions, while dealing with the 'high risk' is possible only through urgent actions.

The computations analyzing the joint action are showed in tables 1 and 2. Table 1 shows the raw values of the area affected by each stressor - high temperature, low precipitations, urbanization and deforestation, of their paired action and of the joint action of three factors. As it has been shown in the previous section, there is no area where all four factors act together. In terms of magnitude, urbanization and low precipitations appear to be the most significant stressors. High temperatures affect approximately half of the area affected by each of them, and deforestations 1/3 of it. The importance of urbanization has been stressed out by other studies (Neamţu, 2005; Grigorescu *et al*., 2012; Petrişor, 2012c; Suditu, 2012). The most important combinations of three factors are the ones between climate changes (high temperatures and low precipitations) and urbanization or deforestation. The joint effect of high temperatures, urbanization and deforestation affects approximately half of the area affected by any of them.

Table 2 sums up the information in table 1 disregarding the nature of stressors and accounting only for the number of factors acting together. It can be seen that as the number of factors acting together increases, the overlapping percentage decreases. Approximately one third of the country is affected by a single factor; the joint effects of two factors cover approximately 4% of the entire territory, and the area affected by three factors acting together makes up only 0.2% of the entire territory. These findings have a practical significance in terms of developing strategies or taking immediate action; it makes sense to act immediately for a very small portion of the territory and develop medium-term strategies for 4% of it.

Tab. 1. Individual and joint effects of high temperatures, low precipitations, urbanization and deforestation against biodiversity in Romania based on geostatistical estimations. Values indicate affected area, in squared km.; the total area of the country is 237,500 km^2. Highlights indicate that a value is not computed if it replicates another one (gray) or the action of a third factor from the right column (light trellis)

Second factor → *First factor ↓*	*High temperatures*	*Low precipitations*		*Urbanization*		*Deforestations*		*Third factor↓*
High temperatures	16158	2322	164	5885	-	1074	-	*Urbanization*
			175		91		-	*Deforestation*
Low precipitations	-	30575		1042	0.0	599	-	*Deforestation*
Urbanization	-	-		31655		275		-
Deforestation	-	-		-		9723		-

Tab. 2. Individual and joint effects of high temperatures, low precipitations, urbanization and deforestation over biodiversity in Romania based on geostatistical estimations. Values indicate affected area, in squared km.; the total area of the country is 237,500 km^2

Number of factors acting simultaneously → *Parameter ↓*	*1*	*2*	*3*
Area summed from all combinations // % of national territory	88111 // 37	11198 // 5	430 // 0
Area excluding overlap // % of national territory	67005 // 28	9908 // 4	430 // 0
% overlap	32	13	0

In summary, the most important drivers of changes found responsible for potential effects against Romanian biodiversity were urban sprawl (consistent with the findings of Neamţu, 2005; Grigorescu *et al*., 2012; Suditu, 2012) and deforestation (also underlined by Roman, 2009; Dutcă and Abrudan, 2010). These factors are characteristic to transition countries (Ehrhardt-Martinez, 1998; Jorgenson and Burns, 2007; DeFries *et al*., 2010; Peptenatu *et al*., 2010), especially when in addition environmental awareness and consciousness are at low levels (Zhao *et al*., 2003; Ianoş *et al*., 2009).

Methodologically, while able to pinpoint hotspots, geostatistical tools have a great generalizing power, which is at the same time their most important limit. The first caveat is that results are theoretical constructs, based on probability estimations, and their limits are not necessarily real and precise (Petrişor *et al*., 2010; Petrişor, 2011). The second issue is causality; while some phenomena can explain the position of hotspots, the reverse is not necessarily true. Spurious hotspots might appear through statistical generalization without proving the existence of a certain process within their limits.

Conclusions

This study spatially overlapped the effects of factors leading to the loss of biodiversity in Romania in order to find areas at highest risk. Climate change (increasing temperatures and decreasing precipitations) and land cover and use changes (urbanization and deforestation) were the most significant ones. Spatial analyses found an area close to the center of the country where all factors acted together, and another in the south, exposed mostly to climate changes. Vulnerable alpine regions were found at risk for the loss of biodiversity. The main causes, urbanization and deforestations, make Romania a typical case study for transition countries. Methodologically geostatistical tools were very useful to map the potential risks. Last but not least, the operational and practical utility of eco-energy in underlining human impacts was reconfirmed.

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THE IMPACT OF CLIMATE CHANGE ON THE EUTROPHICATION OF WATER ECOSYSTEMS IN THE SOUTHERN PART OF THE REPUBLIC OF MOLDOVA

Maria Nedealcov[1], Dumitru Drumea

Key words: climate change, eutrophication, water temperature, atmospheric precipitation

Abstract The accelerating pace of climate change mainly on the adjacent territory of the Danube basin, contribute to the essential eutrophication of water basins within the region. The results indicate that air temperature recorded a double warming compared to territories from the central part of the country. On the background the accelerated warming there is a declining trend and of annual rainfall amounts. These climate changes, especially in recent decades have led to significant increase of water temperature in rivers and lakes. Thus, it constituted in the years 1990-2000 by 0.7 and 1.5^{0}C compared to the period 1980-1990, and by 1.0...2,0^{0}C accordingly in the years 2000-2013 compared to the previous decade. The significant increase of temperature during the last decade contributed to the intensification of algae growth and together with other factors contributed to the increase by about 20% of the nitrogen content, thus ensuring the "flowering" with 50% of the water bodies' volume.

Introduction

Fast tempo of global warming during the XXth century and especially in the early XXIst largely determines the formulation and implementation of national policies related to climate change and its consequences, taking into account national interests. Previous investigations show that adjacent territory from the Danube basin is located "under the influence of maximum global warming". Current pace of warming contributes to establish favourable conditions for the emergence of many invasive species within this area, also there are frequent

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manifestation of droughts- especially intensive ones, and to essential eutrophication in water basins within the region. All these changes in the climate system in the Danube basin can have a significant influence in maintaining ecological security in the region.

1. Investigation materials and methods

Information Data Base concerning temperature and atmospheric precipitation regime in the Danube Basin were statistically processed in the Statgraphics Centurion XV program, Excel (a component of Microsoft Office Professional). Spatial interpretation of the data was conducted through several interpolation methods available in the SURFER 8 and ArcGIS software.

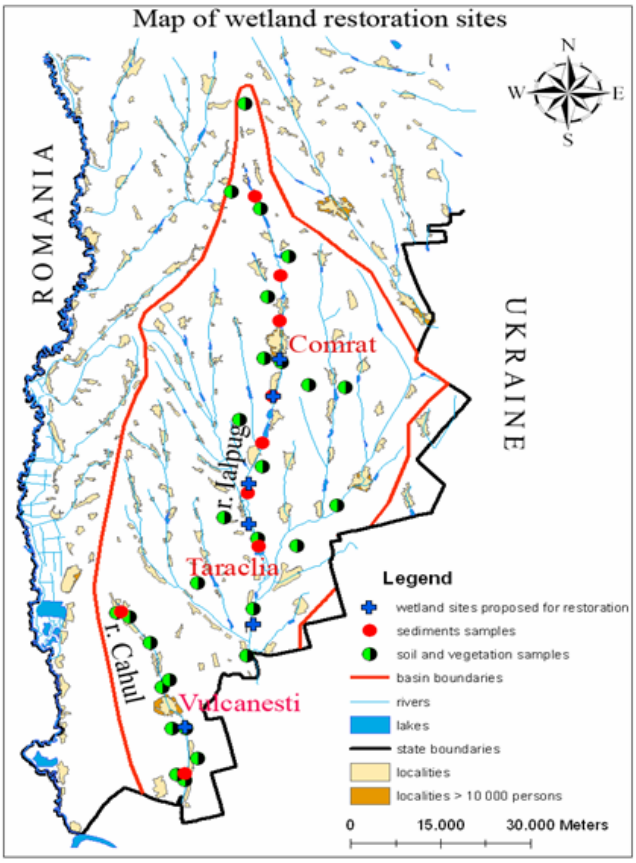

Fig. 1. Collection points of samples on the Republic of Moldova territory

The starting ground material served data regarding average of monthly and decadal temperature, average monthly amounts, daytime maxims, deficit of saturation, number of dry days, and selected samples in different sectors of water basins in order to highlight their eutrophication (fig. 1). The time data series were divided into several periods 1961-1990 and 1980-1999 (according to the IPCC, 2007, 2013), and the period of decades 1989-1999 and 2000-2010 - which according to estimations (Nedealcov M, 2012) are considered the warmest decades in the regional climate. Since the human impact on climate is observed over the republic since the 60s of the XXth century (Constantinov T., 2005), the period of instrumental data series has been conventionally divided into two periods: the natural one (1887-1959) and natural-anthropogenic (1960-2010). Climate evolution from the Danube basin was analyzed compared to the national average.

2. Analysis of achieved results

In the Danube basin within the territory of the Republic of Moldova, there is an increase of annual air temperature values in all analyzed time periods. At the same time, between 1961-1990 and 1980-1999 they basically are the same as the average for the whole country. In the rate of warming significant changes are observed during the first decade of the XXIst century, when it is 0.9^0 more than the rate recorded in the last decade of XXth century (tab. 1) and is the highest rate recorded on the territory (being by 0.4^0 more than the national average). So we notice that at the current stage climate change in the Danube basin becomes to be unpredictable.

Table 1. Assessment (^{0}C) of annual average air temperature change in the Danube basin

Indici statistici	1887-2010	1887-1959	1961-1990	1980-1999	1989-1999	2000-2010	Tempoul de încălzire 2000-2010/1989-1999
X	*9,6*	*9,3*	*9,6* **9,8**	*9,7* **9,7**	*10,2* **10,2**	*10,7* **11,1**	*0,5* **0,9**
σ	*0,8*	*0,7*	*0,8* **0,8**	*1,0* **0,9**	*0,8* **0,9**	*0,7* **0,6**	
X Min.	*7,2*	*7,2*	8,0 **8,2**	8,0 **8,2**	9,1 **9,1**	9,8 **10,3**	
X Max.	*12,1*	*10,7*	*11,3* **11,4**	*11,3* **11,4**	*11,3* **11,4**	*12,1* **12,2**	

Note: X- multiannual average, σ- standard deviation, X Min. – min. value X Max.-max. value
9,6 – average over the republic ; **9,8**- *Danube basin*

The analysis of mean annual temperature – an indicator of warming process, shows that it increases to $0{,}0206^0$C /year, which represents two times more than in the central part of the country.

The sliding values with a periodicity of five years reveal that if in the late 80s of XXth century it is characterized by low thermal background, in recent decades

there has been a stable tendency of growth (fig.1.a) concerning the annual average temperature.

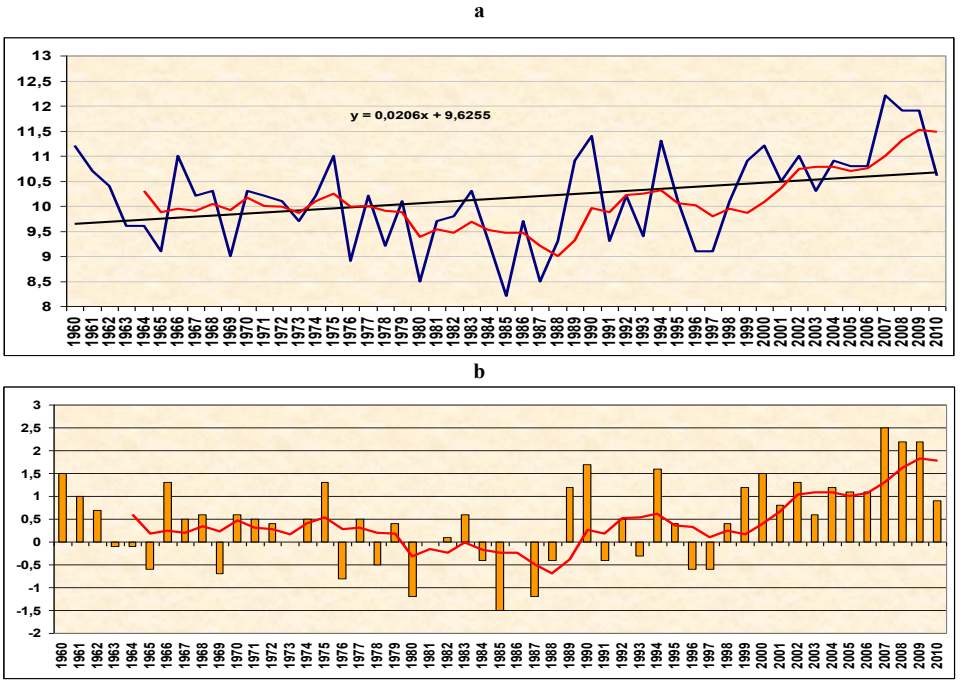

Figure1. The change tendency (1960-2010) in the average annual air temperature (a) and thermal deviations from the climatic norm 1980-1999 (b) in the Danube Basin

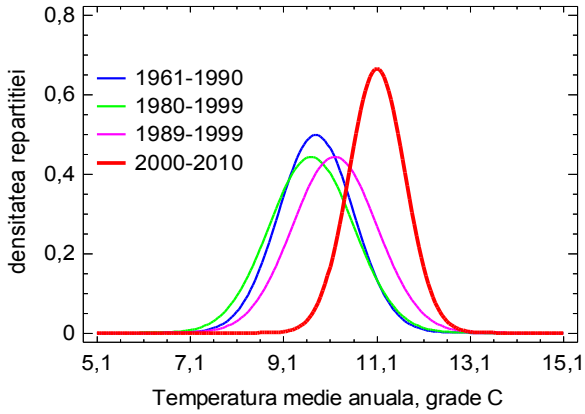

Figure 2. The average annual air temperature deformation in the different periods taken in the research

Analysis of deviations from the climatic norm calculated for the period 1980-1999; reveal that during the last 14 years the average annual temperature in the Danube basin has recorded the most significant positive deviations (fig.1.b).

Such a time-division of the average annual air temperature contributed to climate norms "deformation". The first decade of the XXI century (2000-2010) is the warmest decade for the entire series of instrumental observations, with a doubled warming pace in the last decade (1989-1999) of the XXth century (fig.2).

The main feature of atmospheric precipitation regime and their spatio-temporal distribution is the great variability and their discontinuity in time and space. Precipitation regimes emerge through the interaction of general genetic factors (at the continental level) with local factors. The annual amount of atmospheric precipitation in the region considered in the study reveals some distinct periods where it recorded a significant decline in the first decade of the XXI century (table 2) namely from 530.6 mm in the last decade of the XXth century to 475.7 mm in the first decade of the XXI century. Maximum values in atmospheric precipitation regime (818 mm) were recorded during 1960-1990. The minimum precipitations (307 mm) are recorded in the period 2000-2010.

The analysis of atmospheric precipitation manifestation tendency over the Danube Basin indicates a regional contrary tendency of manifestation, namely by reduction. Thus, for the last 50 years, the Danube basin located within the country territory there is a declining trend in precipitation with the 1.8651mm /year (fig.3.a). Analysis of precipitation deviations shows that in the XXI century; 8 from 10 years have significantly deviated from climatic norm - calculated for the period 1980-1999 (fig.3.b) these values being below 200mm.

Table 2. The assessment of change in annual atmospheric precipitation regime (mm) from the Danube Basin

Indici statistici	1891-2010	1887-1959	1961-1990	1980-1999	1989-1999	2000-2010
X	526,2	503,8	548,2 ***556,3***	555,9 ***534,1***	548,3 ***530,6***	544,2 ***475,7***
σ	122,2	133,1	100,6 ***106,0***	118,9 ***120,6***	128,7 ***151,0***	107,9 ***118,9***
Cv	23,2%	26,4%	18,3% ***19,0%***	21,4% ***22,6%***	23,5% ***28,4%***	19,8% ***25,0%***
$X_{Min..}$	271,8	271,8	361,0 ***360,0***	361,0 ***360,0***	361,0 ***360,0***	407,0 ***307,0***
X_{Max}	915,0	915,0	774,0 ***818,0***	712,0 ***813,0***	711,0 ***813,0***	735,0 ***698,4***

Note: X- multiannual average, σ- standard deviation, Cv- coefficient of variation, $X_{Min.}$ – min. Value, X_{Max}.-max. Value 544,2*—average over the republic;* ***475,7*** *– Danube basin*

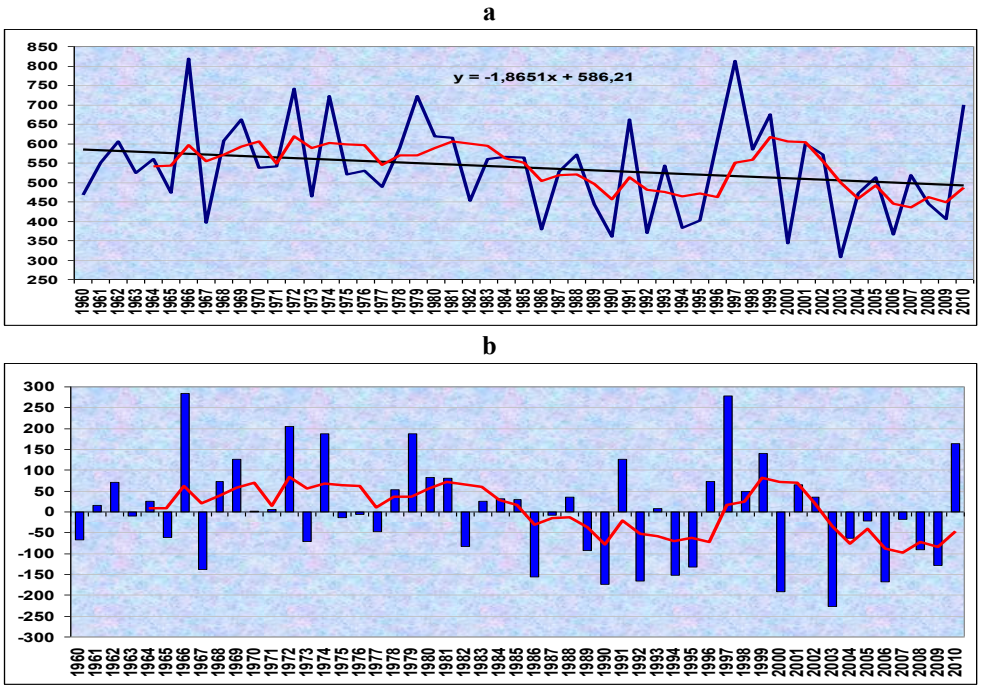

Figure 3. The change tendency (1960-2010) the of the annual amount of atmospheric precipitation (a) and precipitation deviations from climatic norm for the period 1980-1999 (b) in the Danube Basin

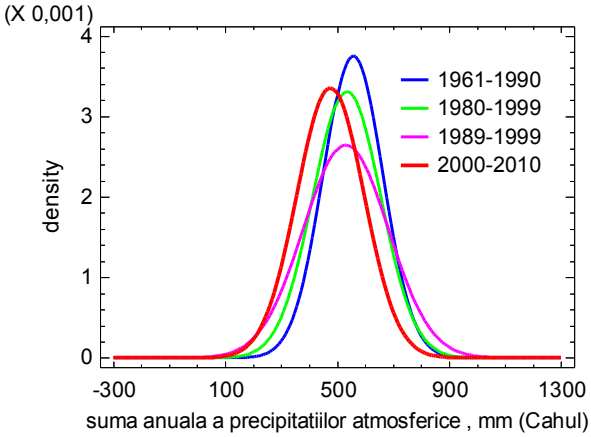

Fig. 4. Deformation of the annual amount of precipitation in different periods taken in the research

The analysis function distribution of annual amounts density that characterize precipitation regime indicates that the period 2000-2010 has a deformation to the left (fig. 4) being the most essential to climate norms, so we can conclude that early XXI century records a significant decrease in the atmospheric precipitation.

Conclusions

In conclusion we notice that changes in the thermal and atmospheric precipitation, contribute to the aridization process intensification in the region. Eventually they have led to the increase of thermal regime of water basins. Comparative analysis of the thermal regime in the Ialpug river and for the lakes located on the Ialpug river basin show its growth in the period 1990-2000 for 0,7 and 1,5 degrees respectively in comparison with the period 1980-1990. In the period 2000-2013 further growing of temperature for 1,0 and 2,0 degrees. The temperature increasing for last decade has contributed to the intensification of algae blooming and together with other factors led to higher content of nitrogen in water for around 20% for the period of last 10 years. Actually siltation covers around 50% of water bodies' volume. This means that there are around 7 mln. tones of sediments in the reservoirs (0-30 cm). The average concentration for N – are 5000 mg/kg and P – 800 mg/kg. Nutrients stocked in sediments (0-20 cm): N – 35 t, P – 6 t.

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ZINC REGIME IN THE SEWAGE SLUDGE-SOIL-PLANT SYSTEM OF A CITY WASTE WATER TREATMENT POND

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Key words: sewage sludge, zinc, pollution, phytoremediation, fertilization.

Abstract: The sewage sludge from wastewater treatment plant of Iasi, a city with 300,000 inhabitants, for domestic and industrial origin, was stored in a mud pond arranged on an area of 18,920 m^2. Chemical analyzes of the sludge showed that, of all the chemical elements determined, only Zn is found at pollutant level (5739 $mg \cdot kg^{-1}$), i.e. almost 30 times more than the maximum allowable limit for Zn in soil and 45 times more than the Zn content of the soil on which the mud pond has been set. Over time, the content of Zn in the mud pond, but also from soil to which it has been placed, has become upper the normal content of the surrounding soil up to a depth of 260 cm. On the other hand, the vegetation installed on sewage sludge in the process of mineralization, composed predominantly of *Phragmites, Rumex, Chenopodium*, and *Aster* species had accumulated in roots, stems and leaves Zn quantities equivalent to 1463 mg Kg^{-1}, 3988 mg Kg^{-1}, 1463 mg Kg^{-1}, respectively, 1120 $mg \cdot Kg^{-1}$. The plants in question represents the natural means of phytoremediation, and sewage sludge as such may constitute a fertilizer material for soils in the area, on which Zn deficiency in maize has been recorded. In addition, the ash resulted from the incineration of plants loaded with zinc may constitute, in its turn, a good material for fertilizing of the soils that are deficient in zinc.

Introduction

Sewage sludge from municipal wastewater treatment plant belonging to Iasi, a city with approx. 300,000.00 inhabitants was deposited in a mud pond located about 2 km from the station, on the land belonging to Tomeşti village, located in the floodplain of the river Bahlui, with an area of about 19 ha. The deposit was built in 1994 by removing the topsoil from an area of 9.1 ha and the construction of dikes surrounding and separating. The deposit was divided into 11 compartments

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with different surfaces. Between compartments there are gaps for water and mud movement. The total volume of the deposit is 225,000.00 m3.

Due to the combined processes of flotation, drying and drainage the sludge has thickened. But the intake of rainfall water contributed largely to maintain a liquid blanket above the mud. As a result of oscillations between the amount of rainfall and evapotranspiration and infiltration intensity, depth of the mud, including water mirror oscillate between 1.5 and 2 m. With time, starting from the basins edges, where the mud in a semi-dry state is prevailing for a longer period of time, has been installed predominantly reed vegetation, vegetation that has developed gradually from the edges toward the center, as the lower prevalence of the liquid phase and the beginning of the soil formation process.

In order to find solutions for greening this mud pond, the sludge was chemically analyzed, leading to the conclusion that of all the chemical elements analyzed only zinc content shows very high levels, with an appreciable potential pollutant effect (Lăcătuşu et al., 2005, 2012) . Therefore, in this paper we present this heavy metal regime in sludge, in plants grown on it and in the soil on which the mud pond has been set.

1. Material and methods

The sludge samples were collected from a drilling rig, carried out of 20 to 20 cm depth of up to 200 cm. From the other five points, also located in the marginal zone of the mud pond, samples were collected only on the depths of 0-20 cm and 20-40 cm. Around the locations where the samples were the half-mineralized sludge were been sampled, plant samples were collected both by species and anatomical parts (root and aerial part). In parallel, soil samples from a profile carried out near the waste area were been collected.

Sludge and soil samples were been analyzed in the laboratory, following determinations being performed: humidity, granulometry after STAS7184 / 10 (1979), the organic C content by Walkley-Black method modified by Gogoaşă, total soluble salts contents by conductometry determination. Mobile forms of nitrogen (NO_3^-), phosphorus and potassium (soluble in the ammonium-acetate-lactate solution at pH 3.7) were determined by ion selective potentiometer (nitrates), spectrophotometry (phosphorus), and flam photometry (potassium), and the total Zn content in soil samples were been measured by flame atomic absorption spectrometry. The total Zn content in plants was carried out in hydrochloric solution resulted by solubilization of plant ash (obtained after several hours calcination at 450°C), using also the atomic absorption spectrometry.

Analytical methods are in accordance with national (STAS) and international (ISO) standards.

Analytical data were statistically computed, statistical parameters (X_{min}, X_{max}, $\overline{X}$ σ, CV, X_g, Me, Mo) and the correlations between Zn contents and sludge and aerial part of plants samples were been investigated.

2. Results and discussions

2.1. Chemical characterization of the sludge and the soil surrounding mud pond area

Sewage sludge is a pasty mass of black or brown color, depending on the intensity of oxidation-reduction process. Sewage sludge has a weak alkaline reaction, a moderate content of $CaCO_3$, but a higher, even very high organic carbon and total nitrogen contents. The higher value of C/N ratio expresses the excess of organic C, which thus increases the ratio of five units from the normal value of C/N ratio of soil existing on the land surrounding the mud pond. There are also characteristic the very large values of the contents in mobile forms of nitrogen, phosphorus and potassium. As compared to the contents of the same chemical parameters in soil, in sewage sludge can be found 22 times more nitric nitrogen, 13 times more mobile phosphorus and 1.2 times more mobile potassium.

Soil, a strongly salinized aluviosol in the depth, also has a weak alkaline reaction; medium carbonates content, but a much lower content of organic C, and almost eight times less than sewage sludge. The humus content (2,8%) of the soil falls into the middle class. Also, the average content of total N falls in the middle class content. Sewage sludge moisture, even at the edge of the mud pond, was nearly five times greater than that of the soil on which the mud pond is placed (Table 1).

Table 1. Chemical characterization of the sewage sludge and of the soil on which mud pond was placed (medium values for the 0-100 cm depth)

Material	pH_{H2O}	$CaCO_3$	C_{org}	Nt	Humidity	C/N	$N\text{-}NO_3$	P_{AL}	K_{AL}	TSC*
		%					$mg \cdot kg^{-1}$			
Sewage sludge	7,38±0,28	7,2±2,4	13,0±1,1	0,84±0,14	128±68	18,4±2,3	66±8,3	174±88	404±87	9090±1300
Soil	8,26±0,21	6,6±2,3	1,68±0,68	0,141±0,05	25,8±7,1	13,4±1,1	3±1	13±6	339±94	7050±7000

*total salts content

Regarding the total salts content (TSC), it is noted that both materials contain soluble salts at high content, i.e. 9g/1000g sewage sludge and 7g/1000g soil, moreover the soil being deeply salinized. These values indicate a very strong salinization in the sewage sludge and strong in the soil.

2.2. The total Zn contents in sewage sludge and in the soil close to mud pond

Analytical data of total heavy metals contents have highlighted the fact that only the zinc content of sludge exceeds the alert threshold value (2.7 times) and even the intervention threshold (1.3 times) for a soil with a sensitive use of the land (table 2). Other heavy metals analyzed recorded average contents even lower than the average content of soil (Cr, Mn), slightly higher than that (Co, Ni, Pb) or high (Cd, Cu), but all below the alert threshold for sensitive land use (table 2). Instead, the maximum zinc content (5455 mg • kg^{-1}) reaches a value that exceeds 109 times the normal content of the soil, 7.8 times the alert threshold and 3.6 times that of the intervention threshold (table 3). However, the grouping parameter values are between 1800 and 1900 mg • kg^{-1} Zn, which indicates that zinc in the sewage sludge generated by this municipal wastewater treatment plant, water that represent a mixture of the domestic and industrial wastewater, is at a very high level of concentration. Industrial wastewaters, although they were initially passed through the factories treatment plants before reaching the city sewerage, however they carried very large zinc content, as a result, in the main, of the zinc coating stations from many existing factories in Iasi city in the past.

Table 2. The medium content of heavy metals ($mg \cdot kg^{-1}$) in the sewage sludge on-going to soil forming process as comparing with the normal contents in soil (NC), with alert thresholds (AT) and intervention thresholds (IT) for a sensitive use of the land

Parameter	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
$\overline{X}$	4,90	16,4	22,5	123	471	39,2	61,2	1905
Σ	1,10	2,3	6,3	17	153	9,8	11,5	1425
NC	0,30	5	30	20	500	20	15	50
AT	5,0	100	300	250	2000	200	250	700
IT	10,0	250	600	500	4000	500	1000	1500

Analysis of the obtained data leads to the conclusion that this sludge despite its high zinc content can be a good fertilizer, especially for the Chernozems soils from the Moldavian Plateau and related geomorphological formations, on which have been reported numerous cases of zinc deficiency in maize (Dornescu et al., 1972).

Installation of wild spontaneous vegetation is a positive signal for the use of such sludge, and at the same time it is a method for reducing the zinc content in the sewage, by its absorption into the plants grown on the mud pond.

Table 3. Statistical parameters of total zinc contents in sewage sludge and soil on which it is filed ($mg \cdot kg^{-1}$), as comparing with the normal contents in soil (NC), alert thresholds (AT) and intervention thresholds (IT) for a sensitive use of the land

Statistic parameter	Zn content in::	
	Sewage sludge	soil
X_{min}	1057	201
X_{max}	5455	510
$\overline{X}$	1903	275
σ	1425	107
CV (%)	75	39
X_g	1875	269
Me	1810	263
Mo	1796	255
NC		50
AT		700
IT		1500

There are known about 500 species of plants which have capacity to accumulate heavy metals and metalloids. These plants can be divided in two groups: a) plants that accumulate chemical elements regardless of whether nutrient substrate may or may not contain such large amounts of chemical elements and b) plants that accumulate heavy metals or non-metals only if nutritional substrate is rich in these types of chemical elements. They have been called optional hyper-accumulators plants of heavy metals and metalloids (Pollard et al., 2014). It also uses the name of phyto-extractors and phyto-remediators plants. In this category can be included *Lolium perenne* for phytoremediation of polluted soils and *Lemna minor* for phytoremediation of heavy metal contaminated wastewater. Researchers conducted by Malschi et al., 2013, under conditions of laboratory experimentation, have highlighted the heavy metals phytoextraction phenomenon from soils and waters polluted by industry.

To this second category can belong even the plants developed on the waste water sewage sludge deposited in the Tomesti mud pond, sludge found in an incipient soil formation process.

2.3. Zinc absorption by the plants developed on the waste water sewage sludge

Excess of water in the sludge (Table 1), originated both from pumping water from the station to the mud pond, but particularly from the rainfall, has created a favorable environment particularly for the reed (*Phragmites australis*), but also, for other grass species such as *Aster panonicum, Rumex acetosella, Chenopodium*

album, Solanum nigrum. There have been reported in small number *Galium aparine, Canium maculatum, Urtica dioica*. The last species multiplied as growing the area lack of water and sludge has been advancing in soil forming process. Moreover, the use of perennials plants in phytoremediation is known (Cho et al., 2006, Baker et al., 2000).

Analytical dates on the average content of zinc in roots and aerial part of the *Phragmites australis* plants (table 4) show that these plants grown on the sludge accumulated 30 times more Zn in the aerial parts, and 46 times more Zn in the root than *Phragmites australis* plants grown in a climate zone close to, but uncontaminated. Therefore, this species may be considered a zinc hyper accumulator plant when nutritive substrate offer very high concentrations.

Table 4. The medium content of zinc ($mg \cdot kg^{-1}$) in *Phragmites australis* plants developed on the waste water sewage sludge and a submerged soil from an uncontaminated area

Substrate	**Analyzed plant organ**	**Zn**
Sewage sludge	Aerial part	473±227
	Root	869±615
Unpolluted submerged soil	Aerial part	16±11
	Root	19±14
Enrichment index	Aerial part	30
	Root	46

Table 5. The values of the transfer (TF) in soil and plant and the root-aerial part accumulation index (RAPAI) in plants grown on the sewage sludge on-going to soil forming process

Plant nature	TF	RAPAI
Aster panonicum	1,14	1,53
Rumex acetosella	3,02	1,84
Chenopodium album	1,54	2,71
Solanum nigrum	1,62	1,91
Phragmites australis	0,70	1,84

Similarly, and the other plants have accumulated large amounts of zinc in both root and the aerial parts (tab.5). For all analyzed species zinc has been accumulated more in the root. Thus, the greatest amount of zinc in the root, as compared with the stem, was accumulated by *Chenopodium album*, followed in descending order

by: *Solanum nigrum, Rumex acetosella* and *Aster panonicum*, as evidenced by the values of the root-aerial part accumulation index (RAPAI) for Zn. The value of this index for *Phragmites australis* is equal to that from *Rumex acetosella* (table 6).

Analyzing soil transfer factor values in the plant (the root and aerial part), we find that the largest amount of zinc was absorbed by *Rumex acetosella* (table no. 6).

Table 6. Average content of zinc ($mg \cdot kg^{-1}$) of the roots and the part of the main plants grown on sewage sludge under soil forming process.

Plant nature	Aerial part	Root
Aster panonicum	860±534	1318±356
Rumex acetosella	2023±615	3732±3000
Chenopodium album	794±167	2148±1785
Solanum nigrum	1063±826	2026±1117

Note that the calculation of these indicators (FT and RAPAI) have used the average values of content for both plant and soil.

Although *Phragmites australis* has a lower amount of transfer factor, as compared to other herbaceous plants, however, the extent of the area occupied by *Phragmites australis* as compared with the other plants, make it important in the process of sewage sludge phytoremediation. Also, its participation in the accumulation of zinc in the summary value of all analyzed plants is 10% in roots and 9% in aerial part (Fig. 1). It is observed that the most amount of the zinc has been accumulated in *Rumex acetosella* (35% in roots and 39% in aerial parts).

Between the levels of zinc in sewage sludge and the levels of zinc in flora installed on it, direct proportionality relationships, statistically assured, have been established (Fig. 2).

The phenomenon of accumulation of zinc and other heavy metals in plants grown on contaminated soil is known (Greger, 1999, Zhao and Mc. Grath, 2009, Dickinson et al., 2009). Moreover, there are indicator plants for the presence of heavy metal accumulation in soil and subsoil, plants used in biogeochemical prospecting.

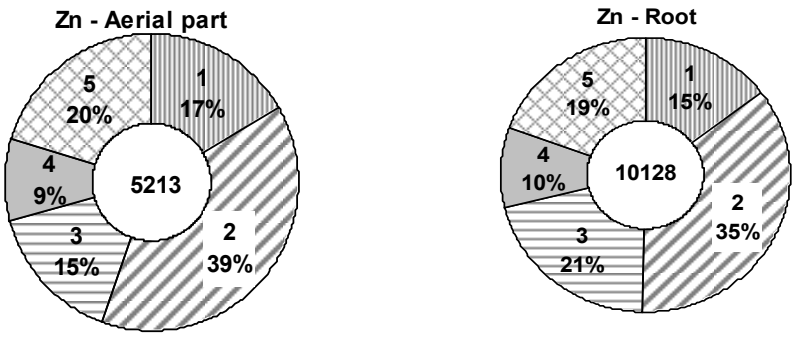

Figure 2. Percentage distribution of Zn contents of the plants grown on the sewage sludge pond from the wastewater treatment plant of Iaşi, related to total heavy metal total (mg·kg^{-1}) accumulated in plants: **1.** *Aster panonicum*, **2.** *Rumex acetosela*, **3.** *Chenopodium album*, **4.** *Phragmytes australis*, **5.** *Solanum nigrum*

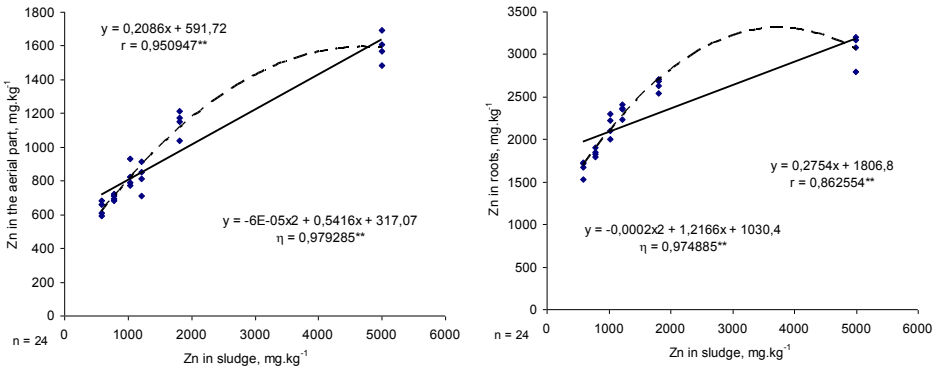

Fig. 3. Correlations between Zn contents in the sludge and in the flora grown on the mud pond

In the case of plants that are growing on polluted soils, plants that accumulate one or more chemical elements, the intimacy of the phenomenon of absorption of the elements considered to be toxic, such as Cd and Pb, or of the elements considered in small quantities as nutrients, is not fully clarified. It is assumed as a first phase that occurs a passive absorption of heavy metals in root with complex flow of chemical elements dissolved in the soil solution. From the root in stems, leaves and in the other components of the plants, heavy metals are driven by so-called "carriers" formed by protein specialized in the transport of each type of metal cation. In this process of the transport and accumulation is involved an enzyme adenosine tri phosphate, from whose hydration result adenosine di

phosphate, free phosphorus and an amount of energy that contribute to heavy metal accumulation. In order to minimize the toxicity of the heavy metals that comes in large quantities in the aerial part of the plant there are involved some genes encoded as HMA_3, HMA_4, which are proteins belonging to P_{IB} type. Moreover, gene HMA_4 with gene HMA_2 also have role in metal translocation from root to the aerial part of the plant (Park and Ahn, 2014).

Therefore, phyto-remediation can be a method of reducing zinc content of sludge reduction which can be achieved only over the course of several tens or hundreds of years, if the harvest is collected every year and cremated, the ashes may be a mineral fertilizer with many chemical elements, among which is distinguished zinc, in particular for soils deficient in this nutritive microelement Lacatusu et al., 2012).

Also, sewage sludge as such, after drying and grinding may constitute an organic fertilizer rich in zinc, applicable on soils of Moldavian Central Plateau, where there have been recorded numerous cases of zinc deficiency in maize. In fact, these conclusions regarding the phyto-remediation of sludge deposited in the mud pond, or its use as a fertilizer in agriculture, after a previous grinding and drying, have been emerged from the early research carried out. (Lacatusu et al., 2005).

Marinciuc et al., 2010, also have reported the possibility of phyto-remediation of sludge from wastewater treatment plants.

Conclusions

- Sewage sludge of municipal and industrial wastewater from Iasi Municipality is deposited in a mud pond with an area of about 15 ha, located in the major floodplain of the Bahlui River on Tomești communal territory.
- Sewage sludge has a weakly alkaline reaction, a medium CaCO3 content, very high contents of organic carbon and total nitrogen, high, respectively medium contents of phosphorus and potassium in mobile forms, and a strong salinization
- Among the contents of heavy metals, only zinc concentration values exceed by 2,7 times the alert threshold value, and by 1,3 times the value of the intervention threshold for the sensitive use of the land.
- On the sewage sludge was installed a predominantly reed vegetation (*Phragmites australis*), and secundary herbaceous, consisting of grass species of *Aster panonicum, Rumex acetosella, Chenopodium album, Solanum nigrum*, species that have absorbed large amounts of Zn in the root and aerial part.
- Vegetation installed on the mud pond with sewage sludge helps its greening through phyto-remediation, absorbing large amounts of zinc. By vegetation incineration resulting an ash rich in minerals, especially zinc, which may be a

mineral fertilizer rich in zinc, applicable on the soils deficient in this mineral element.

- Sewage Sludge after drying and grinding is also a good organic fertilizer to Chernozems of Moldavian Central Plateau on which there have been recorded numerous cases of zinc deficiency in maize.

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THE IMPORTANCE OF WATER TEMPERATURE FLUCTUATIONS IN RELATION TO THE HYDROLOGICAL FACTOR. CASE STUDY – BISTRITA RIVER BASIN (ROMANIA)

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Key words: water and air temperature, Bistrita River, climate change, ice jam, Romania

Abstract. The increase in most components of the climate over the past 50 years, including air and water temperature, is a real phenomenon, as attested by the numerous specialized researches according to IPCC (2013). The water temperature is one of the most important climatic components in analyzing the hydrological regime of the Bistrita River (Romania). The thermal regime of the Bistrita River basin and the frost phenomena associated with the risk factor are particularly important and frequently appear in this area. In recent years, under the Siret Water Basin Administration, this parameter was permanently monitored, so we could do an analysis, which shows that the water temperature fluctuations, influenced by air temperature, lead to the emergence of the ice jam phenomenon. The present study aims to analyze the water temperature, as compared to the air temperature, and the effect of these components on the liquid flow regime (the values were recorded at the hydrological stations on the main course of the Bistrita River). The negative effects resulted from the ice jam phenomenon require developing methods of damage prevention and defense. The frost phenomena recorded after the construction of the Bicaz dam are analyzed in this article.

Introduction

The climate is continually changing, and currently is undergoing rapid modifications because of the anthropogenic causes, which overlap the natural causes. In recent years, at the global level, there are many discussions about the serious effects of the economic development evolution on climate change in the

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future. Many scientists are campaigning for the promotion of appropriate technologies in the sustainable development of human society and for the reduction of polluting emissions that lead to global warming (Al Gore, 2006; Gaume et al. 2009; Feyen et al., 2012; IPCC, 2013; Luo et al., 2013). The impact of climate warming is materialized through: changes in temperature, precipitation, and atmospheric dynamics. The climate risk phenomena will gain intensity and a much higher frequency; the hydrological regime of the rivers will be affected etc. The average air temperature rise on Earth is a real phenomenon, as attested by the numerous specialized researches (Sankarasubramanian et al., 2001; Pandi and Mika, 2003; Zhenmei et al., 2008; Zhang et al., 2011) and the effects of global warming could be catastrophic: large area flooding, prolonged droughts, etc.

Our study area is located in a transitional hydro climatic area, from oceanic influences, more humid and with moderate temperature, to continental influences and major thermal and pluvial discontinuities. In the Climate of Romania an analysis of the evolution of air temperature was made (National Meteorological Administration, 2008) and the result was that, during the 20th century, the temperature on Moldova has a growth of 0.6 and 0.8°C. Because the water temperature is closely linked to the air temperature, it results that the climate change will also affect this parameter.

The water temperature is a very important physical characteristic for rivers, especially if we take into account its influence on aquatic systems. The critical fluctuations that may occur at the level of this parameter, be it of temperature rise over the threshold (maximum accepted water temperature is 30°C) or the low temperatures, lead to the emergence of imbalances in the aquatic systems. The water temperature can be influenced both by human activities, through the discharge of sewage into rivers, and by constructing dams and reservoir (Romanescu, 2005; Webb et al, 2007; Nováky, 2011). The physical-geographical conditions along with the climatic factors from the Bistrita River lead to the occurrence, every winter, of ice forms, which may have different intensities depending on the influence of air temperature over the water temperature. The frequent frost phenomena, which have a significant negative impact on the river Bistrita are the ice jams. The occurrence of these phenomena depends on the climatic conditions, on one hand, and on the other hand on a number of local factors, such as water velocity, water flow rate, the slope of the river, the meanders, the degree of mineralization of underground water, groundwater supply etc. In this study our purpose is to analyze the water temperature fluctuations depending on the influence of air temperature and the negative effects that the frost phenomena have on Bistrita River basin – especially the ice jams.

1. Methods

The water temperature is measured by means of a mercury or alcohol thermometer, with 0.2 degrees subdivisions. In order to obtain accurate values for the temperature the measurement must be done in the stream water and not at the banks level, in the vegetation sectors or in sectors where the water stagnates. In order to measure the water temperature with the thermometer, we have to introduce the mercury reservoir in water and keep it for 5 minutes, after which we do the reading (Zavoianu, 1999). In addition to conventional thermometers, in the last period (starting in 2012), have also been installed temperature sensors, which display the water temperature by means of a dataloger and the data is stored directly on the computer. In the case of classical measurements using the thermometer, measurements are taken twice a day (6 and 17); instead, the sensors record the temperature at more frequent intervals (Siret Water Basin Administration).

The database was made available by the Siret Water Basin Administration, Prognosis, Hydrology and Hydrogeology Bureau. For the present study, we analized information from 7 hydrometric stations on the main course of Bistrita River basin: Carlibaba hydrometric station, Dorna Giumalau hydrometric station, Dorna Arini hydrometric station, Brosteni hydrometric station, Frumosu hydrometric station, Frunzeni hydrometric station and Bacau hydrometric station. The sequence of data has a period of over 50 years.

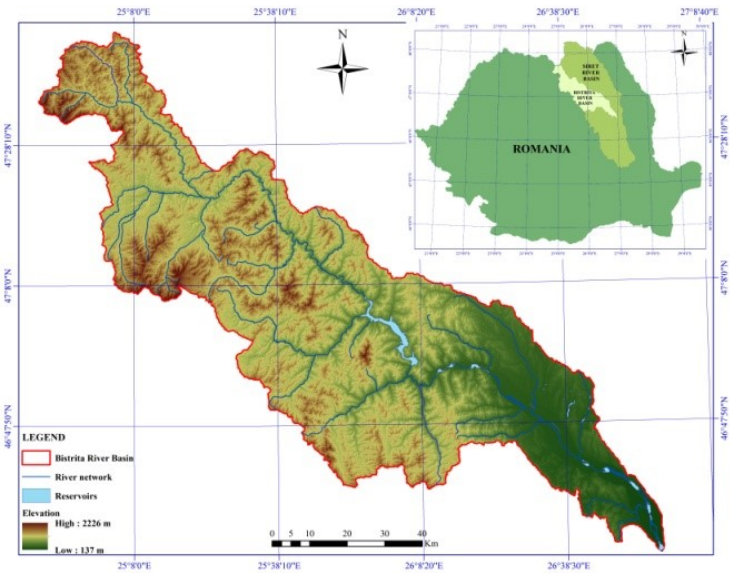

Fig. 1 Geographical position of Bistrita River in Romania

The Bistrita River springs from Rodnei Mountains and flows into Siret 9 km downstream Bacau. From the mathematical point of view, the river basin area falls between the Meridian 24°47'55" longitude E 27°00'49" E longitude and Parallels of 46°29'33" N latitude and 47°44'42" N latitude (Fig. 1). The river basin has an elongated like shape NW-SE direction. The hydrographic network includes 193 tributaries (of which: Dorna, Bistricioara, Cracau, Tarcau, Trebes, etc.). The River is passing through the towns Vatra Dornei, Bicaz, Brosteni, Piatra Neamt, Roznov, Buhusi and Bacau. The basin has an area of 7039 km², 283 km in length, and the average elevation is 919 m (Donisa, 1968; Siret Water Basin Administration).

2. Results and discussions

For the present study, we analyzed the data from 7 hydrometrical stations on the main course of the Bistrita River basin.

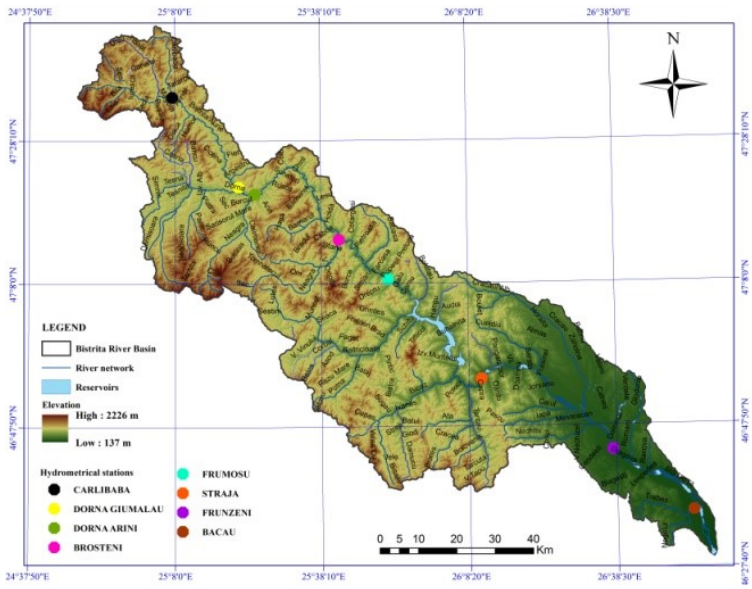

Fig. 2 The localization of the hydrometric stations from the main course of the Bistrita River basin, in Romania

Logically, both water temperature and air temperature are dropping degrees from the source towards the mouth of the Bistrita River. Therefore, the multiannual

average temperature of the water on Bistrita River has the following values: 6.3°C at Carlibaba hydrometric station; 7.1°C at Dorna Giumalau hydrometric station; 7.0°C at Dorna Arini hydrometric station; 8.2°C at Brosteni hydrometric station; 8.4°C at Frumosu hydrometric station; 11.0°C at Frunzeni hydrometric station and 11.4°C at Bacau hydrometric station. Similar to the water temperature decrease is the thermal amplitude decrease having lower values compared to the air temperature.

In the mountain sector the warm season of the year the water temperature is lower than the air temperature, instead, in the cold season appears the reverse situation. In the subcarpathian and plateau areas the air and water temperature values are very similar the first half of the year, from March to July, after which, in August the water temperatures shall be maintained at higher values than air temperature.

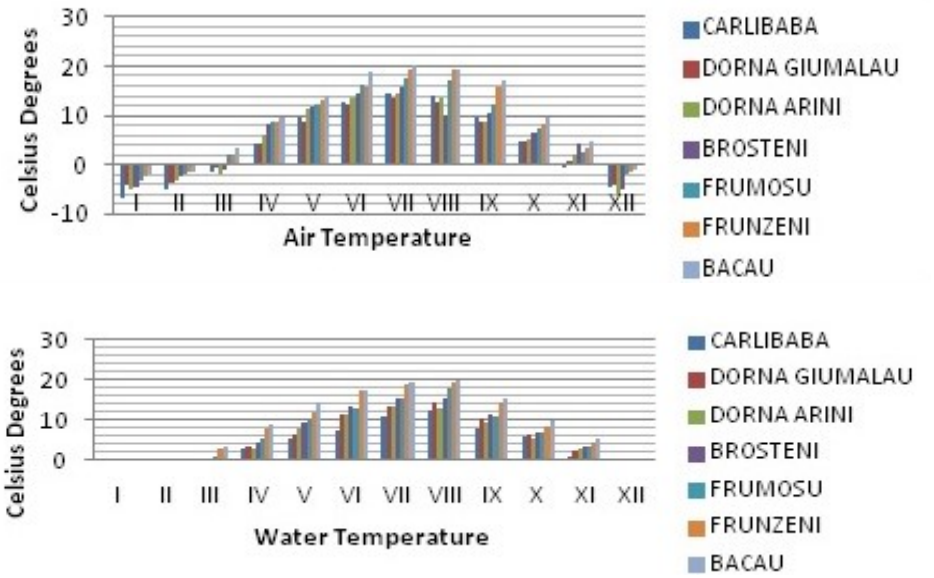

Fig. 3. Comparison between the multiannual average temperatures of water and air at the hydrometrical stations on the Bistrita River at the level of the year 2000

Following a comparative analysis between the multiannual mean values at the level of the year 2000 (Fig. 3), and those from the year 2013 (Fig.4), the conclusion is that the climate change also influences the Bistrita River area, whereas the gradual growth of air temperature and, implicitly, of the water temperature. Another consequence of the climate change is that the frost phenomena start later and disappear earlier.

During the day, the air temperature increases by the hours 1-2 P.M., and then begins to decline, reaching minimum values towards morning, between the hours 5-6 A.M. during summer time and 7-8 A.M. during winter time. Daily the extreme temperatures of the water, unlike those of the air appear with a delay of a few minutes (about 15 minutes), depending on the water flow.

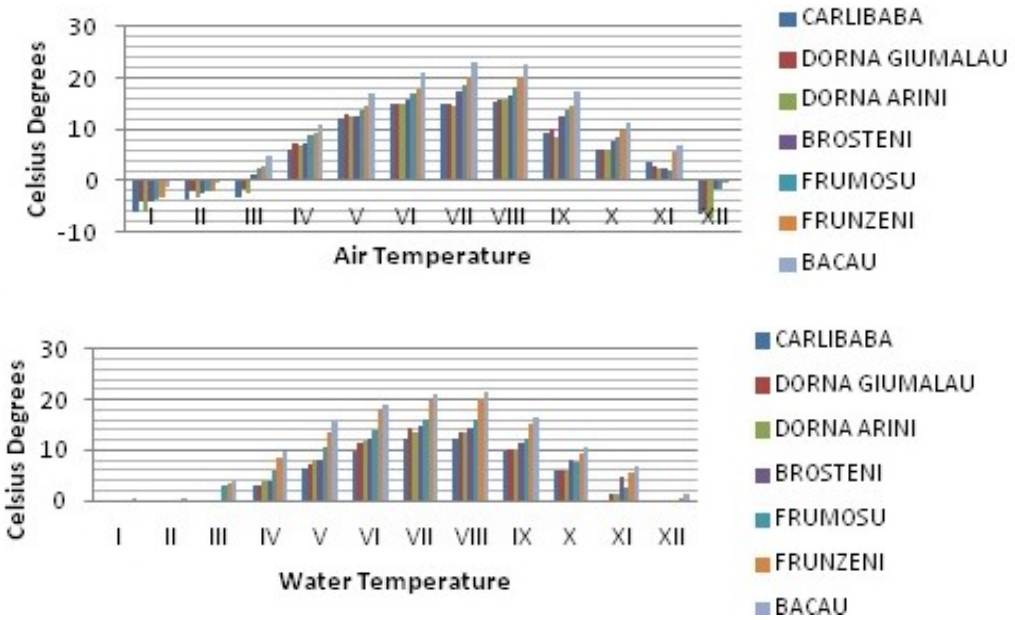

Fig. 4 Comparison between the multiannual average temperatures of water and air at the hydrometrical stations on the Bistrita River at the level of the year 2013

The daily temperature variation graph is similar to that of the air, the exception is that the water temperature values occur later and have slight oscillations. The extreme values of the air temperature are mitigated in the case of water temperature. The same situation can be seen in the case of the monthly changes in water temperature and air. If we analyze the water temperature in the longitudinal profile of the Bistrita River we may notice a decrease in the average temperature of the water, from the mountains sector to the plateau (from the source to the mouth), as a result of the vertical zonality of the rivers' water temperature. In the mountain sector the average multiannual temperature values are 6-7°C and as we approach the mouth area temperature increases up to 8.5-9°C.

The average multiannual temperature variation shows that the lowest temperature values, below 5°C can be identified in mountainous areas – the upper sector of the Bistrita River basin – meanwhile the values increase as we move

towards the plateau, the Bistrita and Siret confluence. From the mountains to the plateau the average gradient of the water temperature increase ranges between 0.5-1°C per 100 meters altitude.

To analyze the variation in time and in space and the thermal regime of the flowing water we must take into account its dependence on the thermal regime of the air. Besides, the water temperature is also influenced by the volume of water in the river, the characteristics of the flow, the intake of water from aquifers, the exposure to solar radiation, the movement of air masses, the characteristics of the cross sections along the longitudinal profile, the influence of residual water (discharged from industrial targets) etc. If we analyze the cross-section profiles on the Bistrita River, there can be seen a sequence of narrower or wider sectors, depending on the geological structure crossed by the river. In the transverse profile, depending on the velocity, the flow, the roughness of the river, in the narrower sectors the water temperature is homogenous, instead in broader sectors there are small differences, noted that in summer, the water temperature is 1-2°C higher at borders than the thalweg, while in winter the situation is opposite.

The maximum water temperatures of rivers usually occur during June and August and vary between 12-22°C in the mountain area and 18-30°C in the subcarpathian and plateau regions.

The minimum temperatures, which are overlapping the winter frost phenomena occur from December to January, even until March in the mountain sector, being around the 0°C or even less so (-2°C) in the mountain areas where the stream velocity is high and the water cannot freeze at the temperature of 0°C.

The frost phenomena are installed when the air temperature falls below 0°C for smaller or longer periods of time, depending on the liquid flow of rivers and the water velocity. On the narrower or smaller tributaries, the installation of the frost phenomena takes place almost simultaneously with the air temperature recording of the 0°C value, since low water volume quickly picks up the negative air temperatures.

Tab.1 The frost period on the Bistrita River

Hydrometrical station	Occurrence date			Disappearance date			Duration (days)		
	Early	Medium	Late	Early	Medium	Late	max	med	min
Carlibaba	6 X	1 XI	28 XI	10 III	25 III	8 IV	165	132	100
D. Giumalau	28 X	22 XI	14 XII	3 III	25 III	6 IV	135	94	53
D. Arini	26 X	12 XI	28 XI	6 III	19 III	31 III	140	110	80
Brosteni	2 X	24 X	15 XI	25 III	7 IV	19 IV	170	140	110
Frumosu	28 X	22 XI	14 XII	3 III	25 III	6 IV	135	94	53

When the air temperature reaches values below 0°C the water freezes. The ice has a density of 0.916 g/cm^3, which is why it floats at the water surface thus forming a protective layer, below which the water has a temperature of between

0°C and 4°C (Zavoianu, 1999). Knowing the relation between air temperature and water temperature of the rivers, when the air temperature registers values below 0°C changes occur in the water temperature regime also. These phenomena occur in autumn-winter period (even in spring, in the mountain area), a period with previously registered negative air temperatures.

Depending on the degree of development, the frost phenomena, which appear on the Bistriţa River are: ice needles, the first stage; bottom ice (appears especially in the mountain areas – at the bottom of the water due to the low velocity, which allows the installation of ice); the border ice; frazil (snow that does not melt in the water); grease ice (groups of ice needles in the water); unfrosted channel; discontinued ice bridge; continuous ice bridge; water over the ice bridge; unfrosted borders (appears in spring, when the temperature rises and the ice from the borders, being thinner, melts); floes; ice jam (an agglomeration of floes in the narrow sectors of the river or at bridges, which obstruct the runoff and produce overflows and floods) (Surdeanu, 2005; Stefanache, 2007; Dumitra, 2008; Raduly, 2010). The last phenomena constitute a risk factor because of their frequency and magnitude. In recent years, in the upstream sector of Poiana Teiului, such ice jams occur almost annually (with different intensities). These are determined by both natural and anthropogenic factors. Upstream the Izvoru Muntelui Reservoirs, the frost phenomena shall be recorded each year with an average of 75 days, the continuous ice bridge occurs less frequently, with an interval of 4-5 years and an average duration of 35 days. This phenomenon manifests itself almost annually from both natural causes and human-induced causes.

The natural causes are: the persistence of very low temperatures (below 10°C) for a longer period of time, leading to the development of compact ice formations; the intrusion of the warmer air masses from the West (Dorna Depression and Bistrita Depression), that causes the increase in water and air temperature from upstream to downstream and leads to the separation of floes and ice jam formations, with sudden increases in water level upstream; high fluctuations in air temperature from day to night and day by day; the succession in Bistrita River of different slope sectors, the existence of meanders and the narrow cross-sections in certain sectors; the Bistrita Depression in the sector between Borca and Poiana Teiului villages is very narrow; the minor riverbed has a width from 50 to 80 meters and a major riverbed between 300 and 1500 m.

The anthropogenic causes are: the presence of bridges, household annexes; the presence, in the area, of unfinished hydropower constructions; the existence of Izvoru Muntelui accumulation influencing the hydro meteorological phenomena in the area. Depending on the intensity, some ice jams produce increases in levels upstream the dams causing flooding and property damage. In addition, problems arise because of the destructive action of the moving floes. Among these must be

mentioned: the destruction of bridges, foot bridges, household annexes, fences, houses (sometimes). Following in time an analysis of the frequency and intensity of the ice jams, in the Bistrita river basin, the most significant developments have occurred in the years 1968, 1995, 2003, and in 2007, 2008, 2009 had lower intensities.

The 25-27 February 1968 ice jam. It formed clumps of floes of 40-50 cm, behind which it has accumulated water. The river level has increased to about 250 cm values over normal situations and remained so for about 10 hours, producing flooding of meadow, of housing and of their annexes.

The December 1995 ice jam. This year there have been ice jams along the Bistrita River up to Poiana Teiului. Agglomerations of ice forms were extended on a 15 km length and because of the impossibility of the Izvoru Muntelui Reservoir to discharge the ice load levels increased upstream. The Bistrita River levels had fluctuations around the attention quota (28 cm over the attention quota).

The December 31, 2002 – January 1, 2003 ice jam was the worst. The length of the built-up ice jam was 13 kilometres upstream Poiana Teiului. The agglomerations of ice thickness was 1-6 m. Houses, household annexes, bridges, foot bridges were destroyed and damaged. It was registered animal mortality. In Poiana Teiului there were 3 human victims.

Fig. 5. The manifestation of Bistrita River ice jam phenomenon

The December 2007 to January 2008 ice jam. The river formed clumps of ice, which led to the formation of blockages from the tail of Izvoru Muntelui Reservoir to Farcasa

locality, in Neamt County, on a distance of 21.1 km and a thickness of the frozen iceland between 0.2 and 6 m.

The December 2008 to January 2009 ice jam (Fig.6). The low temperatures and flow zof the grease ice at the rate of 50-60% of the surface water led to the expansion of built-up areas of ice, reaching a length of 21.2 kilometres up to Pintei locality, in the commune of Borca and a thickness of 0.2 and 5 m. Throughout the manifestation of the phenomenon didn't occur special problems, but the water infiltrations in the cellars and courtyards.

The December 2009 to January 2010 ice jam. The negative temperatures from the Bistrita River basin led to the emergence of the grease ice that led to the formation of blockages for a 14.8 km length from the tail of the Izvoru Muntelui Reservoir to the Vadu Rau Bridge, with thickness between 30-40 cm. There were no reported damages.

Fig. 6 The manifestation of Bistrita River ice jam phenomenon 2008-2009

Starting from the causes, conditions and evolution, the ice jams can be controlled and prevented by various means. We cannot intervene in the natural causes, as they will keep in the future, but if we refer to the morpho-hydrographic and hydraulic conditions of the riverbeds, here we might intervene with a number of changes. The issue in this case is that such works are costly and can have negative side-effects (for example: ensuring the high velocity increase of the runoff leads to riverbed processes, bank and thalweg erosion etc.).

Most measures are at hand: the removal of obstacles of riverbeds or on the banks (fences, household annexes); proper sizing of bridges and foot bridges; removal of built-up ice jams in order to avoid their development etc. During the evolution of the dangerous ice jams overseeing their permanent evolution is necessary in order to be able to announce and timely take the necessary measures downstream. In the most serious cases people from areas at risk are evacuated.

Conclusions

The thermal regime of the Bistrita River basin and the associated frost phenomena represent a risk factor particularly important and frequent in this area. The present study analyzed the water temperature, as compared to the air temperature, and the effect of climate change on the liquid flow regime (the values were recorded at the hydrometrical stations on the main course of the river Bistriţa).

The ice jams develop on an annual frequency, sometimes even two or three times a year on the Bistrita River upstream the Izvoru Muntelui Reservoir, on the state of hydro meteorological conditions of the basin. The length of the river on which the ice jams appear reaches up to 25 kilometers, blocking entire sections of the riverbed. The agglomerations of ice thickness reach up to 5-7 m in critical areas, where the bed is narrow and meandered. The existence of Izvoru Muntelui accumulation makes it difficult to unlock the ice formations, when it has ice bridge in the tail. This phenomenon manifests itself violently when unlocking the ice blocks and leads to flooding with economic, social and human damage. Because of the the very low water flow rate (10-15 m^3/s) during this period, the ice formations cannot float or move and remain blocked on the thalweg.

The most significant developments have occurred in the years 1968, 1995, 2003, and in 2007, 2008, 2009 were less intense. The negative effects of the ice jam phenomenon require developing methods of prevention and reduction. Human intervention for the reduction of the effects of these phenomena is limited because non-structural measures are useful for the short term period; meanwhile structural measures involve some very high costs.

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THE IMPACT OF WEATHER AND CLIMATE RISKS ON CEREAL CROPS PRODUCTIVITY

Maria Nedealcov [1],

Key words: climate risks, impact, productivity, cereal crops, weather.

Abstract. Increase the intensity and frequency of the weather and climate risks contribute to compromised harvests in recent decades. Analysis of financial losses indicates that in 2007 and 2012 substantial values were reached. In this context it is important to know their regional peculiarities of manifestation both in present and in the years to come. The results shows that pronounced manifestation of the weather and climate risks in recent years (2000-2013) contributed to the decline of winter wheat harvest of 2q / ha compared with the harvest that is expected in the 2020s - calculated according to the most drastic SRES B2A scenario. The results are extremely necessary to take adaptation measures to new climatic conditions and to food security for the future in the Republic of Moldova.

Introduction

The agriculture, the main branch of national economy, as in the European Union countries, faces some serious environmental challenges, the main of which are: deficit and competition for water resources, climate change and lack of adaptation strategies to these changes, at local and regional level. According to (IPCC, 2013), climate change is already happening and will continue to happen; even if greenhouse gas emissions will be reduced. The impact of climate change on agricultural sector shows that these effects vary between different regions at different scales. Overall, changes in agricultural production highlight the vulnerability of food security (Tachie-Obengi E et all., 2010), showing a reasonable concern that climate change and associated climate risks represent threat of the poverty to sustainable development; also it refers also to our country (Nedealcov M., 2014).

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In the Republic of Moldova, more of the national agricultural production consists of cereal and industrial crops and the weather and climate risks remain to be ones of the most important reasons that affect agriculture.

1. Investigation materials and methods

Harvest formation is a very complicated process largely determined by the crop biology and agro-meteorological conditions of the territory. In natural conditions with unstable moisture regime crops not fully realized their biological potential, according to the results previously obtained. Deviation from the optimal weather conditions causes decrease or total loss of crop productivity. This statement highlights the productivity modification from year to year. Overlapping of crop productivity, evolution of the multiannual thermal and precipitation regimes reveals influence of agrometeorological factors on the crop formation. In this context, it is important correlation of climatic factors with crop productivity in order to highlight their role in the production process.

In estimating the role of meteorological factors in the formation of productive process, in accordance with well known methods in the field of Agrometeorology (Pasov V., 1973), the harvest (Y_i) of agricultural crops is considered as the sum of two components. This can be explained by the following expression:

$$Y_i = Y_i^{(T)} + \Delta Y_i^{(T)}, \qquad (1)$$

where $Y_i^{(T)}$ is shown as the average dynamic, determined by the tempo of agricultural development and climatic conditions close to multiannual average, and deviation from it - $\Delta Y_i^{(T)}$ is explained by favourable or unfavourable weather conditions, expressed as positive or negative anomalies in the harvest.

Simulations of grain crops harvest were conducted through SRES Scenarios.

Because the duration of dry days during May-August, directly influences attending the main crops ontological stages, Dry Periods Index (Izu) is proposed (Nedealcov M., 2012), which represents the ratio between their sums recorded in the concrete years by their multiannual data for the period indicated above. This index has the following expression:

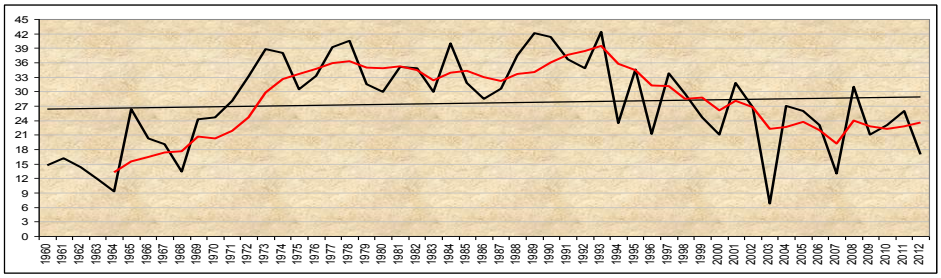
$$Izu = \frac{\sum zu_{(V-VIII)}}{\overline{\overline{X}}zu_{(V-VIII)}}, \qquad (2)$$

where $\Sigma zu_{(V\text{-}VIII)}$– amount of dry days during the period (May-August) when the crops intensive growth and development is held, Izu (V-VIII) - annual average of days dry (May-August).

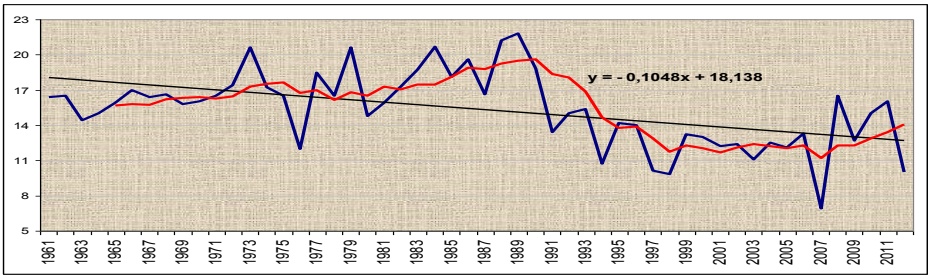
3. Analysis of the results

Therefore, it was considered that in years with positive anomalies in productivity, agrometeorological factors were classed as favourable and vice versa negative anomalies in the productivity was determined by excess or deficiency of some of agrometeorological factors manifestation (unfavourable years).

a- winter wheat



b-sunflowers



c- maize

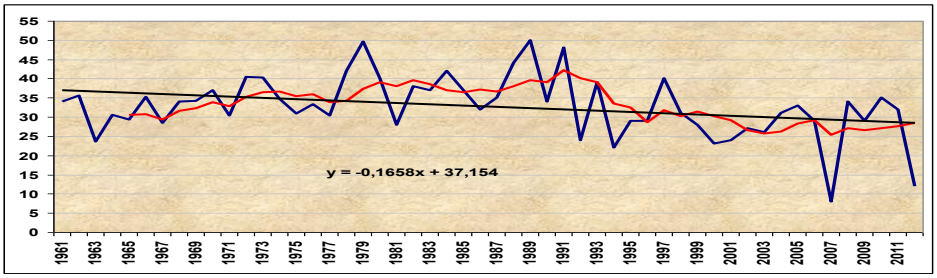


Figure 1. The modification tendency of the agricultural crops harvest taken in the study

Causes of harvest minor anomalies from the average dynamic are usually difficult to establish and it is considered that could be explained by the failure to comply of level of cultivation, pests influence, etc.

Removing them (conventionally) by trend component and estimation of positive and negative anomalies in the harvest crops during optimum or extreme

years in terms of weather, was highlighted a close correlation relationship between environmental factors and the agricultural crops production.

Thus, it was found that the combined risks from 2007 and 2012 (high temperatures and lack of rainfall for a long time) contributed to the fact that corn and sunflower crops had the lowest values during the period of 1961- 2010 (Figure 1). For winter wheat we add and the year 2003, when due to the weather and climate risks during the winter also were established dry conditions in the generative phase (fig.1).

Thus, the highly variable thermal and rainfall regime, especially in recent decades, has contributed to the emergence of climate change associated risks, especially droughts. According to the Department of Emergency Situations of the Republic of Moldova, among climate risks that have manifested in recent decades (1998-2013) in three years droughts contributed to the economic losses. Thus, the drought of 2002 damaged the country of about 2126.3 lei, the drought of 2007 caused material losses of 1002090.8 lei but material damages in 2012 were the most significant, and amounted 1,252,076.9 lei (fig. 2).

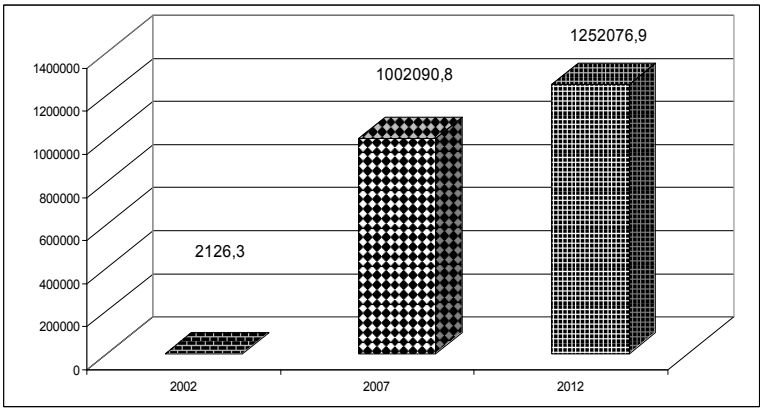


Figure 2. Material losses recorded after the worst drought conditions manifestation during the years 1998-2013

In the XXIst century, the highest share of total material loss from the total weather-character risks over the Republic of Moldova, are droughts of 2007 and 2012. The separate analysis of climate risk manifestation for these years reveals that in the above nominated, material losses are generated from the manifestation of three risk categories.

a

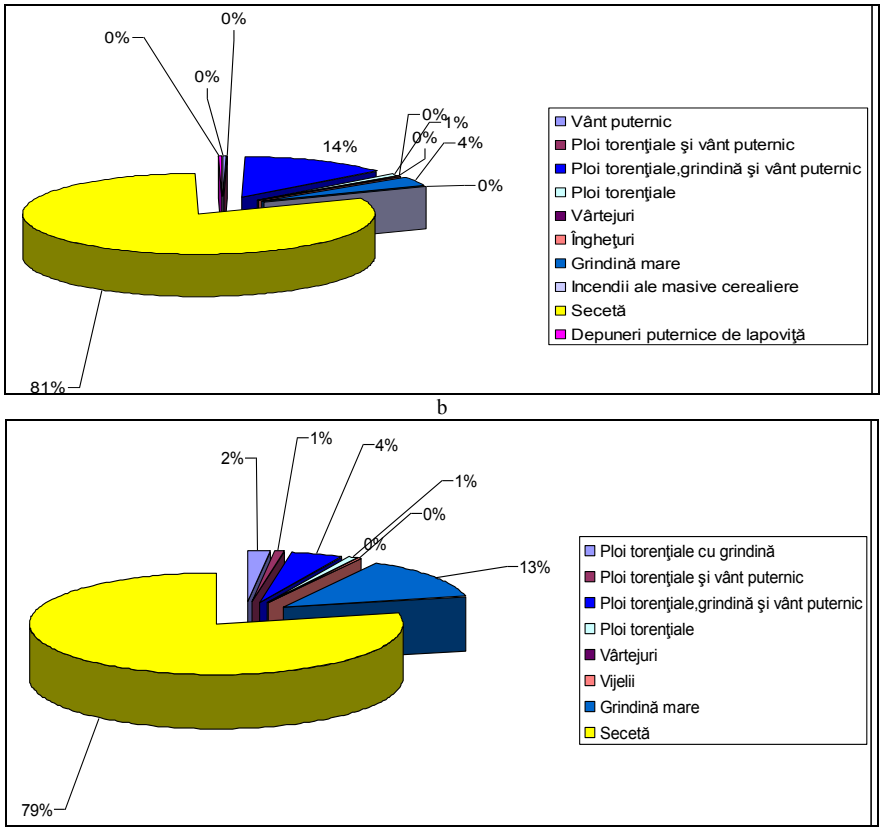


Figure 3.Share of material damages due to the drought of 2007 (a) and the drought of 2012 (b)

Thus, in 2007, in addition to material losses caused by drought (81%), 15% of the losses were because of torrential rains accompanied with other risks such as strong winds or hail, and about 4% of damages due to large size hail manifestation, non combined with heavy rains (fig. 3a). In 2012, about 79% of the material damages are caused by the manifestation of drought. As in 2007, besides torrential rains that contributed to 8% of economic losses and about 13% of the economic damage has inflicted large hail (fig. 3b).

Table1. Thermal extremes at different stages of climate evolution

The stages of climate evolution	T min. abs.	T max.abs.	At
I 1960-2010	-17.2	34.2	51.4
II 1989-1999	-16.8	34.4	51.2
III 2000-2010	-24,2 2006 -21,8 2010	36,3 2009 36,6 2001 36,6 2010 37,2 2002 37,5 2008 38,5 2000 39,5 2007 42.4 2012	53.5

Measurement of the extreme values modification (tab.1) in the Moldova's climate evolution indicates that absolute maximum of temperatures have a regular manifestation on the last period (2000-2010).

Increasing the climate continentally determine the estimation of saturation deficit (fig. 4), analysis which shows that it is constantly growing, since the 80s of the XX century, more pronounced being observed during first decade of the XXI century (in the central and the southern part of the country) that denotes the intensification of the aridity processes in the Republic of Moldova.

Correlation of annual values of saturation deficit with that of the number of dry days indicates the close relationship the correlation between these two parameters (0.8) throughout the country.

The estimation of saturation deficit (mb) duration, concomitant evolution with that of the dry days' number indicates the increase values of these two climatic components since the 80s of the XX century, and by end of the first decade of the XXI century records the essential practical values throughout the country (fig.4).

In parallel with the evaluation of spatio-temporal saturation deficit in the study were studied and the number of dry days during the active growing season for the months of May to August- the critical period, in terms of aridity and dryness for the growth and development of many crops groups. We mention that "dry days" are considered to be those days when temperatures are high (air T > 25^0C) and low relative air humidity (Ur < 30%) being considered as days with negative over of ontogenesis phases evolution.

a

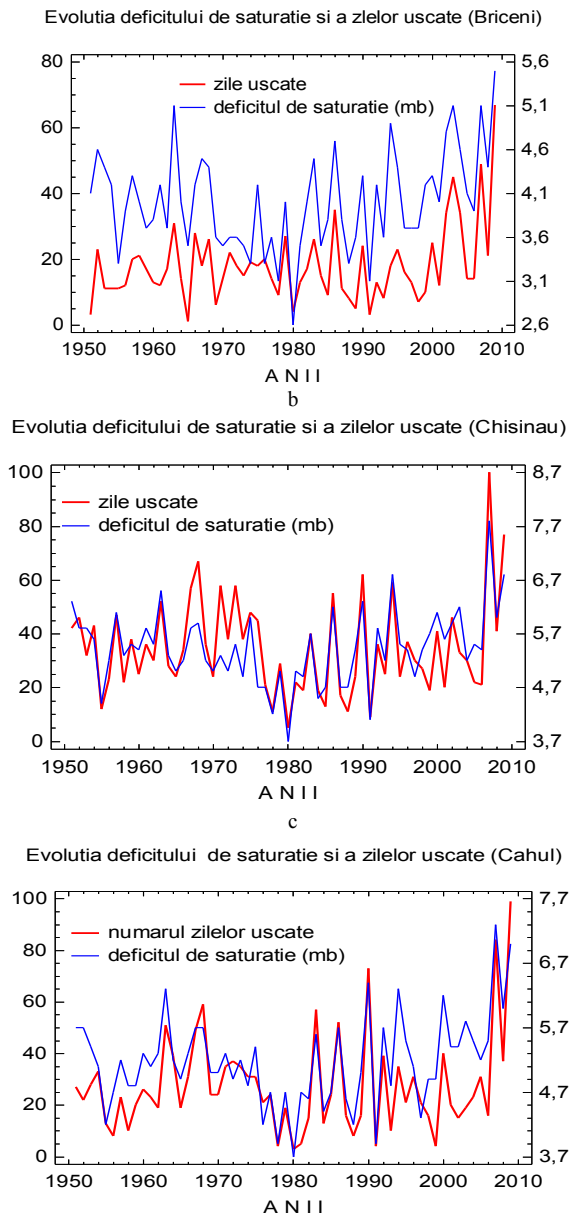


Figure 4. Evolution of saturation deficit (mb) and dry days over the Republic of Moldova (a-Briceni, b-Chisinau, c-Cahul)

Because the duration of dry days during May-August, directly influences attending the main crops ontological stages, Dry Periods Index (Izu) is proposed, which represents the ratio between their sums recorded in the concrete years by their multiannual data for the period indicated above.

Table 2 Dry Periods Index Ratings (Izu) by M.Nedealcov

Values *Izu*	Ratings ***Izu***
0,1-1,0	Normal period
1,1-2,0	Moderate dry period
2,1-3,0	Significant dry period
3,1-4,0	Dangerous dry period
>4,1	Exceptional dry period

Izu Ratings allow highlighting periods of aridity of dry days. So if Izu values = 2.1 the sum of dry days double exceeds their annual average, by setting up a significant dry period (table 2).

Izu dynamic analysis demonstrates that in recent years it exceeds the limit of very dry periods and in the South of the country even, the limits of dangerous dry periods (fig.5).

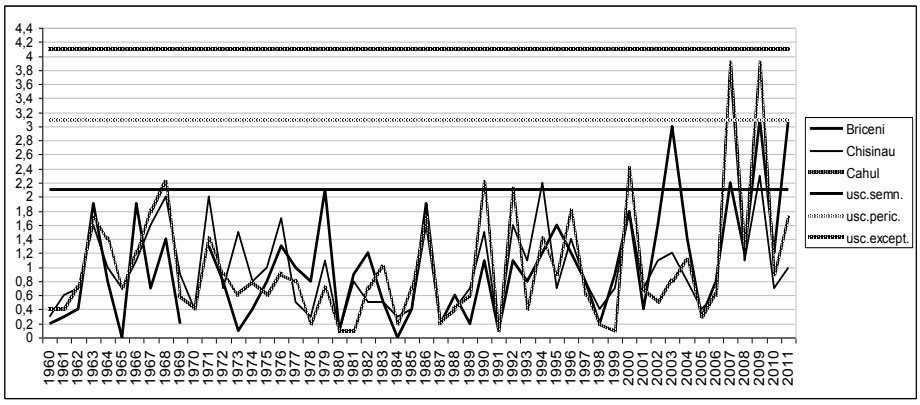


Figure 5. Temporal analysis of Izu

Izu cartographic modelling, for example in 2007, indicates that only in the north, in the months of May to August were established significant dry conditions (fig.6).

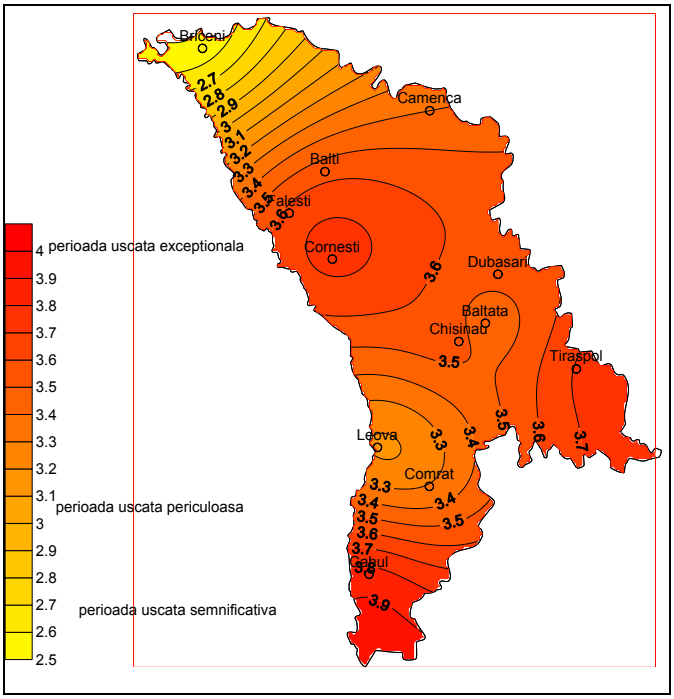


Figure 6. Cartographic Modelling of Dry Periods Index (Izu) in 2007

So, the impact of climate change is a major problem at present and it is a global issue, while conducting the prognostic character estimation could prepare mankind in carrying out adaptation measures and food security. Recent researches at the section climate change impacts on cultivation of certain crop groups reveal that these occur more rapidly than previously was anticipated. Crops harvest, according to these results, it is directly influenced by many aspects of climate change, resulting predominantly from: average temperature increase, significant variability in rainfall regime, increasing of CO2 atmospheric concentrations, the variability of extreme events associated with climate change. Increasing average, maximum and minimum temperatures are expected for countries with unstable humidity regime, which includes and the Republic of Moldova, a fact confirmed by previously researches. Is projected that in such regions, where water availability is reduced, to a warming of 2 C in this century (Parry M., et all, 2004), some of the agricultural land will become unsuitable for crops grown. This will be largely due to increased evapotranspiration and decrease of soil moisture levels, leading itself to crop yield reduction. We note in this context, that the magnitude of these

decreases, unfortunately, is still unknown, but some analysts suggest that they could be quite severe.

Therefore, changes in temperature and precipitation associated with the permanent CO2 emissions will bring changes to agricultural land suitability for maize development. According to the IPCC Special Report on associated emissions (SRES, 2000) and climate models designed to increase of global temperature (Quirogaa S., et all, 2007), some simulations of corn and wheat with reference to the Republic of Moldova.

According to these estimates, in the next years (2020), a drastic decrease in the yield of maize and winter wheat is expected - according to scenario SRES B2A (tab.3, tab.4), and by the 2020, corn yield will be about 25% less than the yield calculated for the period of 1970 to 2000 - period taken as the reference in projections calculations (http://sedac.ciesin.columbia.edu/data/collection/crop-climate/maps/gallery). Thus, in value expression of the real yields, if the annual average during the period 1970-2000 constitutes to the winter wheat 32.9 q / ha throughout the country, according to the majority SRES scenarios for 2020 (A1F SRES, SRES A2B, SRES B1A, SRES A2A, B2B), the autumn wheat harvest will decrease by 2.5 q / ha. According to the less drastic scenario, for the same period, autumn wheat harvest over the Republic of Moldova will decrease by 1.3 q / ha, and in the scenario SRES B2A - by 2020, the harvest may decrease by 8.2 q / ha. Unfortunately, we find, however, that the autumn wheat yield calculated for the period 2000-2012 already is 22.7 q / ha thus by 2 q / ha less than the yield calculated with the most drastic scenario SRES B2A, which reveals that in the 2020 within the limits of Republic of Moldova could be yield of 24.7 q / ha.

Likewise, in the case corn harvest, that calculated for the whole country already calculated for the period 2000-2012 is 26.4 q / ha, thus 0.2 q / ha less than the yield calculated for the most drastic scenario (SRES B2A) which show that in value expression corn harvesting could be 26.6 q / ha by the 2020s. We note that the average yield of maize calculated for the entire period taken in the study (1960-2012) is 32.8 q / ha, in recent years, however, (2000-2012) it has decreased by 6.4 q / ha.

In the case of winter wheat yield changes design at regional level for the period 2080, according to scenario SRES A2A even have a positive prognostic yield by 1% from the annual average. More drastically, SRES B1A Scenario projects namely a decrease of -30 ... -20% from the annual average. In the case A1F SRES, SRES A2B, SRES A2C - the autumn wheat yield will decrease by -5 ... -3%, and in the case SRES B2A and B2B - it expected to decline to -10 ... -5%.

Thus, the real value expression yields, if the annual average during the period 1970-2000 throughout the country is 32.9 q / ha, According to the majority SRES scenarios for 2020 (A1F SRES, SRES A2B, SRES B1A, SRES A2A, B2B), the

autumn wheat yield will decrease by 2 5 q / ha. According to the less drastic scenario, for the same period, autumn wheat harvest in the Republic will decrease by 1.3 q / ha, and in the scenario SRES B2A - by 2020, the harvest may decrease by 8.2 q / ha.

Table 3.The simulation of maize harvest for the years ahead

		Intervalul de timp		
	Scenariile propuse	**2020**	**2050**	**2080**
1.	SRES A_1F	-10... -5	-30...-20	-30...-20
2.	SRES A_2B	-10... -5	-30...-20	-30...-20
3.	SRES B_1A	-10... -5	-30...-20	-30...-20
4.	SRES A_2A	-10... -5	-30...-20	-30...-20
5.	SRES A_2C	-10... -5	-30...-20	-30...-20
6.	SRES B_2A	-30...-20	-30...-20	-30...-20
7.	SRES B_2B	-10... -5	-30...-20	-30...-20

Table 4.The simulation of winter wheat harvest for the years ahead

		Intervalul de timp		
	Scenariile propuse	**2020**	**2050**	**2080**
1.	SRES A_1F	-10... -5	-10... -5	-5...-3
2.	SRES A_2B	-10... -5	-10... -5	-5...-3
3.	SRES B_1A	-10... -5	-10... -5	-30...-20
4.	SRES A_2A	-10... -5	-10... -5	-1...+1
5.	SRES A_2C	-5...-3	-10... -5	-5...-3
6.	SRES B_2A	-30...-20	-10... -5	-10... -5
7.	SRES B_2B	-10... -5	-30...-20	-10... -5

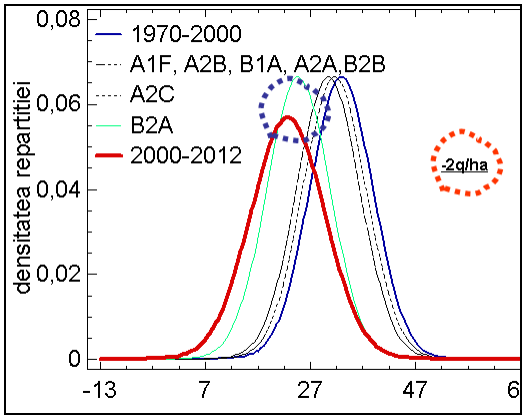


Figure 7. The analysis of winter wheat harvest distribution density

Unfortunately, we find, however, that the autumn wheat yield calculated for the period 2000-2012 already is 22.7 q / ha thus by 2 q / ha less than the yield calculated with the most drastic scenario SRES B2A, which reveals that in the 2020 Moldova harvest limits it would be 24.7 q / ha.

In conclusion we note that regional climate change represents one of the major threats to sustainable development and is one of the biggest environmental problems, with negative consequences for the national economy.

Conclusions

Besides the fact that currently is preparing the third National Report on Climate Changes, at the national level, unfortunately there are no lows that would take into account the priority of this environmental issue; we do not have the strategy of adaptation to climate change and realisation the 10-year strategic plan and framework to enhance the implementation of the Desrtification Convention in national level.

SWOT analysis	
Strengths	**Opportunities**
Shows that the strength is the fact that the country's produc-tion potential climate offers high value crops, especially fruits and vegetables, which present an important thing for increasing farmers' income - agriculture, the basic industry of the national economy.	The main opportunities noted that now, of the agricultural sector is a major potential but largely untapped and unused. Efforts to increase the competitiveness of Moldovan agricultu-ral products, given the new climate conditions will lead to a transformation of Moldovan agriculture highly productive and profitable business.
Weaknesses	**Threats**
Weaknesses are conditioned by the fact that the country is vulnerable to a number of risks negative impacts on rural incomes, including droughts, floods, hails, which in the context of current climate change show a higher intensity and frequency. Yield per hectare is low compared to other countries in the region varies greatly every year, which indicates lack of mechanisms for adaptation and mitigation of climate change and risks in agriculture.	And threats are: Possible natural disasters such as drought, floods, hail, etc. Lack of intersectorial national strategy to reduce the impact of climate change and risks. Agricultural practices that do not take into account the possible negative effects of climate change on soil, environment and biodiversity is a serious threat to sustainable development.

SWOT analysis shows that the strength is the fact that the country's production potential climate offers high value crops, especially fruits and vegetables, which present an important thing for increasing farmers' income - agriculture, the basic industry of the national economy.

Weaknesses are conditioned by the fact that the country is vulnerable to a number of risks negative impacts on rural incomes, including droughts, heavy rains, hail, frost, floods, which in the context of current climate change show a higher intensity and frequency. Yield per hectare is low compared to other countries in the region varies greatly every year, which indicates lack of mechanisms for adaptation and mitigation of climate change and risks in agriculture. The main opportunities noted that now, of the agricultural sector is a major potential but largely untapped and unused. Efforts to increase the competitiveness of Moldovan agricultural products, given the new climate conditions will lead to a transformation of Moldovan agriculture highly productive and profitable business.

And threats are: Possible natural disasters such as drought, floods, hail, etc. Lack of a intersectoral national strategy in order to reduce the impact of climate change and risks. Agricultural practices that do not take into account the possible negative effects of climate change on soil, environment and biodiversity is a serious threat to sustainable development.

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TYPES AND FORMS OF RELIEF ON GHERASIM TORRENTIAL VALLEY, TÂRGU OCNA

Mară, M [1], Dârlău, Oana [2]

Key words: types and forms of relief, Gherasim torrential valley, Târgu Ocna

Abstract. The present study brings new data regarding the landforms occurring on gypsum rocks through the action of denudation processes. The landforms signaled complement the domain literature with natural dams, vertical shafts and reappearing springs, developed at the contact between the Subcarpathians and Berzunţi Mts. The presence of the gypsum dam has slowed down the intensity of erosion processes upstream, in comparison to the neighboring valleys. The analyzed area has also an educational importance, offering sufficient objectives for the knowledge of the local characteristics or for field applications. The perimeter presents sufficient objectives also to be included on the list of protected areas of national interest.

Introduction

1.1. Scientific and practical importance

The study and putting into circuit of geographical knowledge on the fields situated in the North-West side of Târgu Ocna town has imposed by the originality of forms of relief present, which are related to the presence of plasters in the lithology of the area. Their high friability and solubility determines a rapid damage of the petrographic relief formed on these rocks. The reduced thickness of plaster layers and their position from the contact between mountains and Subcarpathians facilitate a large extension of denudation processes that determine a rapid damage of these forms of relief. The perpendicular position of plaster and freestone layers, compared to the discharge direction of Gherasim valley, allowed the individualisation of a natural levee, the waters discharged on the versants of Gherasim valley infiltrating through a sink-hole positioned at the upstream basis of the natural levee and the infiltrated waters get out through a Karstic intermittent spring at an altitude lower by 28 m from the sink-hole. In the upper part of the

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natural levee there is a dissolution doline, with the diameter of 9 m and with a depth of 2 m. We can observe the multitude and diversity of forms presented in this space of only 8 ha, which confers it a didactic importance (for pupils and students) and for tourism.

The preservation of functionality of this natural levee is also important for the preservation of current ecosystems upstream the natural levee (forests and grasslands), by the creation of a local base level, which, compared to Nistoroaia valley from the West side of the natural levee, is higher by at least 20 m.

1.2. Geographical positions and limits

The studied sector is situated between 26°35' 11'' and 26°11' 33'' east longitude and 46°18'24''și 46°18'40'' North latitude and represents a torrential valley without permanent discharge, developed at the contact of Carpathian orogen to the neogene one. The transom we refer is delimited at the north side by Gherasim Hill, continued towards east by a saddle which makes the pass towards Nistoroaia peak. From this limit peak, it orients towards south, on the crest and the south versant, up to the confluence of the three brooks, Rugiului, Nistoroaia and Gherasim, and the west limit is represented by Nistoroaia torrential valley.

The catchment basin of Gherasim valley is placed on the submontane glacis below Ceir Peak and is drained towards Vâlcele brook, affluent of Trotuş on the left side (Fig. 1, Fig. 2).

Fig. 1. Gherasim torrential valley, upstream the natural levee.

1.3. Research history

In the country, the presence of karstic relief composed by plasters was signalled by various geographers. The most frequent forms of relief are the lapiès,

the dolines and the wadis, with a strictly punctual extension.

Grigore Posea and collab. (1976) signals that on plaster, salt, sulphur and other sulphides, lapiès, dolines and uvalas are formed at the surface, and in the interior part, small hollows and karstic grottos, to which is also added a specific morphology, conditioned by human intervention (pits, fallen salt pits, wells, galleries). Traian Naum and Mihai Grigore, (1974), highlight the plaster relief in the following locations:

– on Valea Stânii of Mezeșului Mountains, there are present lapiès with crests smaller than 2 cm and 2 dolines, of which the largest in the form of an elongated ellipsis signalled I.Viehmann and I. Mac (1966);

– in the vicinity of Cheia Village (Cheile Turzii), on the saddle between Hășdatelor Valley and Valea Lungă, dolines with diameter of 100 m and a depth of 15 m are present;

Fig. 2. Location sketch Gherasim torrential valley.

V. Trufaș (quoted by Naum and Grigore, 1974) signals the presence of some dolines and slopes developed at the contact between Muscelele Argeșului and the crystalline of Făgăraș Mountains, on the interfluves between Vâlsanului Valley and Râul Doamnei. Dolines are signalled at “Găurile Șteurului” and variable dimension dolines are found at Muchea Șesului (with a diameter between 1 m and 15 m and a

depth from 0.5 m to 7 m) or blind torrential valleys. In this area, at Nucșoara, in Măgura area, there are also two dolines, the larger one quartering Învârtita Lake and the other, Gaura Măgurii, is drained by a brook, with intermittent discharge.

For Moldova area, forms of relief created by plasters intercalated to the Miocene, on the space of Tazlău-Cașin Depression, from the north side of Valea Rea up to Bălăneasa valley, under the form of dolines, slopes and lapiès. They are isolatedly found in Carageaua Hill, in Săliște Hill, from the west side of Răchitiș village and in Chirtog Hill from Schitu valley (Brânduș, 1981). Lapiès were signalled at the upper part of Perchiu Hill (Grozavu, 2003). An incipient doline and lapiès are also present at south side of Trotuș, in Podeac Hill, from the south side of Bogdănești locality (Mară, 1999; Grozavu, 2003). The presence of a cave as karstic form was also signalled. It was discovered by professor R. Pușcariuc, having a length of about 30 m, is positioned on the forefront of the terrace of 80 m, on the left side of Oituz, off Filipești village (Grozavu, 2003).

1.4. Research methods

The research of the corresponding perimeter was carried out by direct observation, topographical survey and plotting. It was considered to obtain a topographic plan at the scale 1:1000, the mention of relief fragmentation depth, both along Gherasim valley, as well as related to Nistoroaia valley from the west side. This plan was used to locate the karstic interest objectives, the 15 pedological profiles performed and the limits were drawn as regards the extension of soil units, necessary for the appreciation of surface soil erosion classes. By the direct observation action, the extension of parental materials was delimited for the soils, which allowed considerations on the extension of submontane glacis, from the east of Ceir Peak.

2. Natural factors

2. 1. Tectonics and lithology

The geotechnics of the perimeter is closely related to the evolution of flysch deposits and pericarpathian molasse (sandstone), from the area of Carpathian geosyncline, the foreland being the Moldavian Platform. The peri-carpathian unit is saddled at west by the external flysch, representing the autochthon for it (Băncilă, 1958; Mutihac, Ionesi, 1974).

Stiric movements (badenian) produced the thrust of Tarcău nappe, which covered a great part of the external flysch (Vrancea unit). The majority of areas uncovered by thrust become dry, and the sedimentation area from the east becomes the pericarpathian foredeep, which shall be filled by neogene sediments. Their diversity (conglomerates, freestones, clays, evaporites, etc.) expresses the rhythmicity of sedimentation intensity. They are composed of rock fragments, with variable dimensions and course and an uneven cementing (Săndulescu, 1962).

Moldavian movements from the end of Volhynian intensely folded the deposits from the foredeep and generated a thrust to the molasse, with the entire structure of flysch layers from the west of foreland margin. At this moment begins the edification as land of Subcarpathians, which during Volhynian and Basarabian transformed into land, in contact with Sarmatian Sea from the east. In this large area of dry contact, a succession of adjoint deltas were formed, under the action of river that were descending from the Carpathians, the future piedmont between orogen and the platform.

The Walachian movements from the lower Pleistocene (Liteanu, Ghenea, 1967), the entire molasse area was edified as land. Tazlău - Caşin depression acquires the current morphological appearance by the occurrence and erection of Pietricica Crest and Ouşorul Massif, fact that allowed the organisation in the depression of the hydrographical system of Tazlău at the north and of Oituz at the south, all tributary to Trotuş. The formation of this hydrographical basin represents the start up of modelling processes within the entire subcarpathian space, being initially removed the piedmontane deposits, then there was passed to the modelling of molasse deposits.

The lithology of surface deposits was identified during the execution of soil profiles, being identified four categories of rocks, their extension having hall-marked the soil cover, influencing especially the physical and chemical characteristics, represented by:

– plasters, extended compactedly on the area of 870 sq m, on Nistoreasa Peak and being mixed with other rocks, on the area of de 490 sq m, on the south bevel of the natural levee;

– the clays represent the most extended rock from the researched perimeter, with compact extension in the basin of the valley, upstream the natural levee, where they occupy 5.98 ha and, being mixed with other rocks, on the area of 8820 sq m, on the south bevel of the natural levee:

– calcareous freestones, present only on the south bevel of the natural levee, where they extend on 490 sq m;

– fine skeleton clays, present only in the upper basin of the valley, in the space from which the submontane piedmont was not completely removed.

2. 2. Geomorphology

Gherasim torrential valley is positioned on the south prolongations of Berzunţi Crest and it is drained towards Trotuş River, through Vâlcele brook. The genesis of subcarpathian relief was greatly produced in Quaternary, when the removal of the greatest part of piedmontane cover took place, the further evolution of forms being produced under the influence of neotectonic movements and of lithologic variety,

within the tectonic compartments and on hydrographical basins, general feature characteristic to new regions exposed to a violent denudation as the Subcarpathians, to the relief dynamics and the land use potential (Badea, 1983).

The evolution of Gherasim valley in Quaternary. The distribution of surface lithological materials and the soil erosion condition highlight the intensity of denudation processes, triggered by the local level of Trotuş valley. The land inflexions and the low harshness of lithological deposits allowed the installation and rapid depthing of Vâlcele valley, on the areas occupied by the Pleistocene piedmont. The continuity of denudation process produced the removal of the greatest part of piedmontane deposits and the denudation unearthed massive plaster deposits, where crests are individualised, having determined direction changes for some secondary valleys, tributary to Vâlcele brook. The Pleistocene piedmont preserved in the upper third part of Gherasim valley, where the character of the valley is consequent and the present lithology is represented by fine clays with fragments of uncarbonated freestones. These deposits extend from the west limit of torrential basin up to the altitude of 460 m. The lands from the east side of Pleistocene piedmont are occupied by clays, plasters and freestones that got outside because of intense denudation. After the erosion of piedmontane deposits, the transfer direction of denuded materials was kept, towards Vâlcele brook, but the overlaying of plaster crests on the left side of the valley determined the change towards the south of course orientation. The denudation processes and the depth of the valley continued until the thalweg of the valley reached the benchmark of 410 m, where it intercepted a thick layer of about 10 m of plasters and freestones, and the fissuration of these rocks allowed the infiltration of rain waters into the rock bank, through a sink-hole which is positioned at the altitude of 401 m. The northern slope of the natural levee has a height of 9 m. The waters infiltrated into the sink-hole reappear, in a Karstic intermittent spring, below the south slope of the natural levee, at benchmarks of 373 m, the underground route having an altitudinal fall of 28 m.

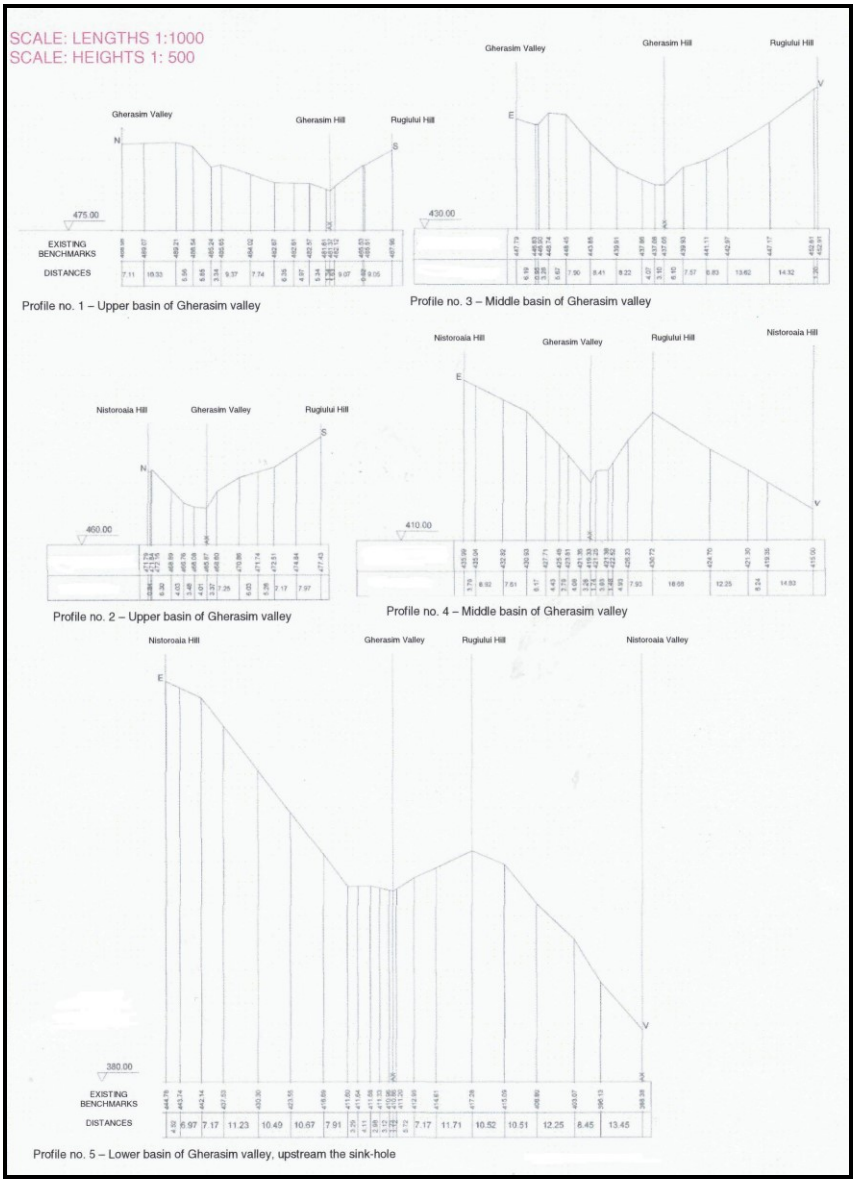

Fig. 3. Transversal profiles

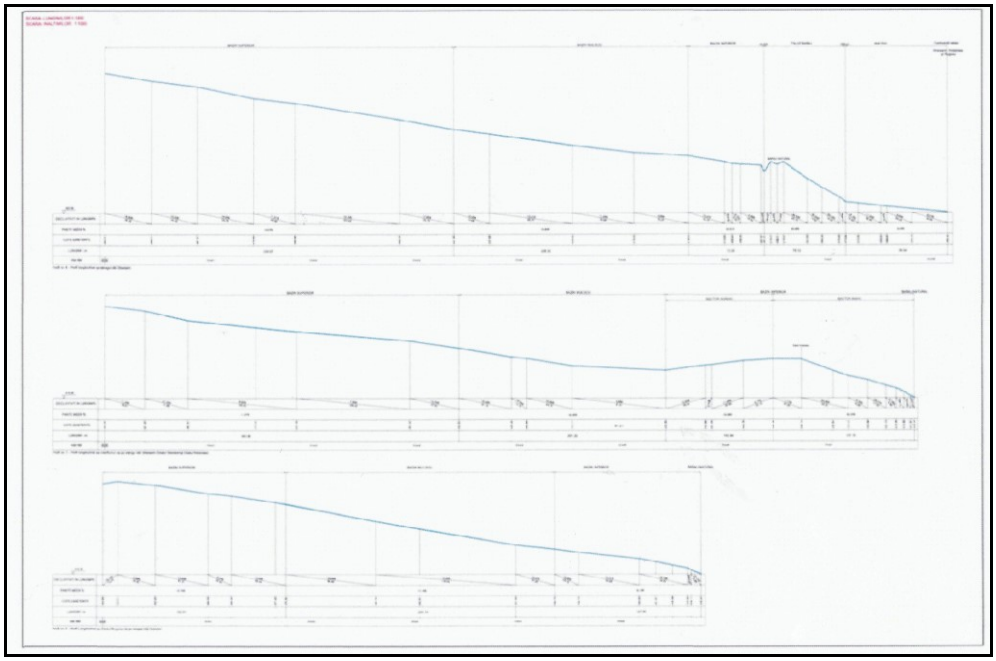

Fig. 4. Longitudinal profiles

Fig. 5. Thresholds of 0.1-1 m on the talveg Gherasim valley, upstream the sink-hole.

Fig. 6. The doline developped of the natural levee.

Morphography. The crests delimiting Gherasim valley are secondary, are contoured from the upper basin and they detached from the surface of the piedmontane glacis, as a result of depthing of valley thalweg. On the left side of the valley, the interfluvial crest is evenly reduced towards east, in the upper basin, in

Gherasim Hill, with an average tilt of over 11 %, then the slope is maintained at over 10% in the entire saddle between Gherasim Hill and Nistoroaia Peak and it has the average value of over 26 % between Nistoroaia Peak and the natural levee of plasters. The crest on the right side of the valley (Rugiului Hill) has a permanent altitudinal decrease, but the lowest slopes are found in the upper basin (almost 13 %) and the highest tilts are found in the lower basin, of over 18 % (Fig.no.3, Fig. no.4). Gherasim valley is a torrential valley, with discharge only during rainy periods, for which the thalweg slope has values of over 15 % in the upper basin, of 10 % in the middle basin and of over 20% in the lower basin, upstream the natural levee, where more ridges are present with unevenness of almost one meter each (Fig. 5, Fig. 6). Downstream the Karstic intermittent spring, the slope is only of 10 %. The connection between the crests and the valleys is achieved through versants, with expositions imposed by the orientation of crests, which are affected by the areolar erosion and partially by the depth erosion, small failures and landslips.

Morphometry. The basin of Gherasim torrential valley is altitudinally disposed between 500 m at the upper limit, towards Ceir Peak and 364 m at the confluence of Gherasim, Nistoroaia and Rugiului brooks. If the highest altitudes are present in the piedmont space, in the middle and lower basin, the highest altitudes are present on the crests which have plasters in their axis.

The depth of relief fragmentation. It must be presented only for the sector upstream the natural levee. If in the upper basin it has values of 6-7 m on both valley versants, in the middle sector they have the tendency to increase, exceeding 12 m towards Gherasim Hill and 18 m towards Rugiului Hill, in the saddling area between Gherasim Hill and Nistoroaia Peak, it comes back to over 10 m and upstream the natural levee, the depth of fragmentation has approximately 8 m towards Rugiului Hill and almost 34 m towards Nistoroaia Peak. The fragmentation depth from Rugiului Hill towards Năzărioaia valley is of almost 30 m. The presence of the natural levee protected the upstream lands, while on Nistoroaia valley, the free denudation determined the descent of the thalweg by approximately 25 m, with the corresponding extension and of the adjacent versants.

Land slope. Totally, the basin of Gherasim torrential valley is positioned on inclined lands between the values of 5-15 %, present on the saddle from the northern interfluve, up to values of 95%, found on the versants at the south of the natural levee. This element, together with the vegetal cover and human activity, have a deciding importance in the determination of soil preservation condition.

The morphogenesis is determined both by the characters and processes imprinted on the lithological structures, as well as by the action of climate, hydrological and anthropic factors (Fig. 7).

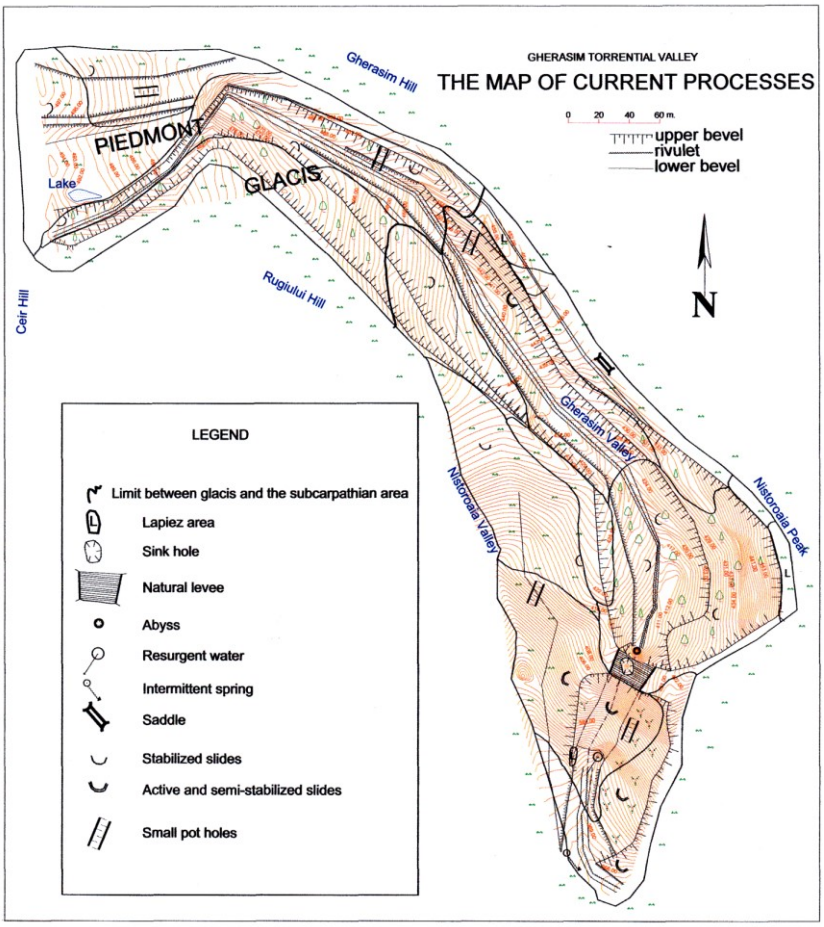

Fig. 7. The map of current processes.

The petrographic relief, determined by the presence of plasters, is Theimportant for the entire Moldavian subcarpathian area. The intercalation of plasters layers in the neogene molasse, sometimes with important extensions, allows, on the Gherasim torrential valley area, the formation of a plaster relief, represented by lapiès, doline, natural levee, sink-hole, Karstic intermittent spring, intermittent character springs. In the entire torrential basin, no springs are found.

The lapiès (Fig. 8) have lengths of the most 10-15 cm and depths of 3-5 mm and they are positioned on appearances of plasters from Gherasim Hill (north-west of the saddle), in Nistoroaia Peak and on the versant at the south of the natural levee. The low harshness of these rocks makes that the denudation destroy rapidly

the walls bordering the lapiès.

The doline (Fig. 9) was identified in the space of the natural levee, it has a diameter of 9 m and a depth of 2 m, and it seems to be formed by the dissolution processes taking place because of quartering of waters discharged from the versants.

The natural levee was formed because of the failure of the torrential debit to penetrate the massive plaster and freestone layer and the existence of cracks in the lithological deposits allowed the infiltration of pluvial waters in a sink-hole positioned at the north side of the natural levee.

Fig. 8. Lapiès

Fig. 9. Te doline developed on the natural levee

By denudation and suffosion, the altitudinal position of the sink-hole became deeper, thing that determined the creation of the northern wall of the natural levee, with a height of 9 m at present. The natural levee protected the lands upstream it, aspect which is obvious if we compare the altitude of thalwegs in the two torrential valleys, Gherasim and Nistoroaia (Fig. 10). The sink-hole, situated under the wall upstream the natural levee, represents a gap of about 15 cm in width, from where the water infiltrates underground, at the altitude of 401 m. The Karstic intermittent spring is positioned under the south wall of the of 373 m, the water travelling in the interior of the natural levee an altitudinal difference of 28 metres.

Fig. 10. Difference of depthing of Gherasim and Nistoroaia valleys

Fig. 11. Left versant of Nistoroaia brook

Within the researched perimeter, we also found an intermittent spring, on the thread of Nistoreasa valley, which has a continuous flow during rainy periods, with variable flow rate, and during draught periods it is discontinuous, with water ejections at the interval of 2-3 seconds.

The fluvio-denudational relief is the most extended relief type from the natural levee, being the product of the denudation process action by which there were formed, within the sculptural relief, interfluvial apexes and crests and versants, and the accumulation relief is represented by Pleistocene glacises and current glacises. The versant processes within the perimeter are represented especially by surface erosion, depth erosion and landslips (Fig.11).

The surface erosion completely affects the surface of this basin (of 8.523 ha) and it is generated by the discharge of pluvial waters at the soil surface, on slopes. The extension of erosion classes, taken over from the areas occupied by soils is the following:

- low erosion, present on 1.977 ha, namely 23.19 %;
- the moderate erosion, occupying 1.992 ha, namely 23.37 %;
- strong erosion, extending on 3.148 ha, namely 36.94 %;
- very strong erosion, occupying 0.426 ha, namely 5.0 %;
- excessive erosion, resent on 0.98 ha, namely 11.5 % of the total eroded lands (Fig. 13).

It can be noted that the weakly-moderately lands occupy about 46.5%, and the strongly, very strongly and excessively eroded lands have a significant weight, against the entire preponderance of grasslands and forests. The area of lands with very strong erosion, situated at the north-west of the basin, still keeps the routes of the baulks, which were delimitating the lots of grass lands, areas where the uncontrolled pasturage and deforestations of forest stand, have determined the occurrence of argic B horizon and the creation along the lots, in the middle area, of

some small gullies, by water concentrations, at the level of each lot of previous use.

Depth erosion. As a whole, the entire area of Gherasim torrential valley can be classified as an active, deep, partially stabilized sink-hole. The perimeters actively affected by the depth erosion, under the form of gullies with the depth of 0.5-1 m are located in the lower and upper basins of the valley, where they occupy the area of 2.546 ha, namely almost 30 % of the researched perimeter. The lands in the upper basin are occupied by forests and those in the lower basin, at the south of the natural levee, are barrens. The forms under which they manifest are gullies, the lands having sometimes the appearance of badlands (Fig. 12). The area affected by depth erosion represents:

Fig. 12. Badlands areas in the upper basin of Gherasim torrential valley.

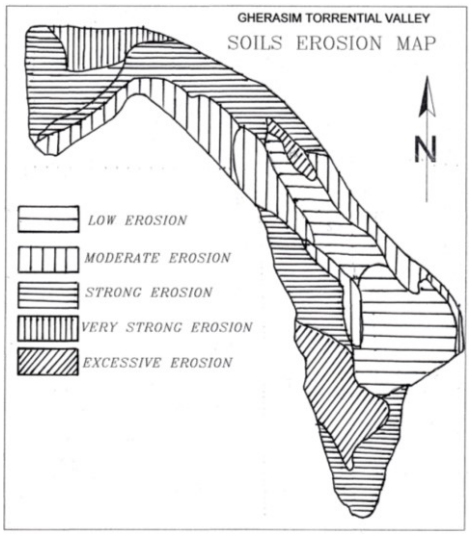

Fig. 13. Soils erosion map.

Landslips are important because they change the form of the versant and the hydrological regime of it, generating mixtures of soil horizons. The great extension of clays, the exceeding regime of precipitations, the land tilting and the current use of lands offer optimal conditions for the production of landslips.

As a whole, in the basin area, the landslips extend on 6.308 ha, namely 74 % of the total. According to the observations from the field, the landslips have the sliding bed situated at 1-2 m in depth and, according to the form and stability degree, three sliding classes have been separated:

- landslips in stabilized waves, present on 4.731 ha, namely 55.50 %;
- landslips in semi-stabilized waves, occupying 0.597 ha, namely 7.0 %;
- landslips in semi-stabilized waves, locally with failures, extended on 0.980 ha, namely 11.50 %, of the entire basin. Locally, between the landslip waves, small temporary lakes are present.

Within the areas affected by landslips, we can notice the great weight of lands with stabilized slips (75.0 %) and the lands with semi-stabilized slips extend on 25.0 %.

Depth erosion. As a whole, the entire area of Gherasim torrential valley can be classified as an active, deep, partially stabilized sink-hole. The perimeters actively affected by the depth erosion, under the form of gullies with the depth of 0.5-1 m, are located in the upper and lower basins of the valley, occupying the area of 2.546 ha, namely almost 30 % of the researched perimeter. The lands in the upper basin are occupied by forests and those in the lower basin, at the south of the natural levee, are barrens.

The forms under which they manifest are gullies, the lands having sometimes the appearance of badlands. The area affected by depth erosion represents:

- small gullies with rare density, on 1.566 ha, namely 18.37% and
- small gullies with high density, occupying 0.980 ha, namely 11.50%.

The glacises are forms of accumulation of eroded materials from the versants. According to age and petrographic composition, two categories of glacises were distinguished in Tazlău Depression (Brânduş, 1981):

- old, formed in Pleistocene, strongly fragmented and eroded, positioning the upper basin of the torrent, where in the fine clay mass are present fragments of skeleton with low course degree. This glacis is present in the erosion destruction phase.
- new, Holocene, with material deposits only on the bottom of Gherasim valley, which has widths of 1-3 m, where low silting processes take place. The slope of the thalweg, of over 10 % on the entire route, ensures almost the entire transportation of the solid debit towards Vâlcele brook.

Conclusions

The catchment basin of Gherasim valley is situated on the submontane glacis below Ceir Peak and it is drained towards Vâlcele brook, left affluent of Trotuş. By the movements from the end of lower Pleistocene, the entire subcarpathian area was edified as land. By the partial erosion of Pleistocene piedmont, in the middle area of the hydrographical basin of Gherasim valley, crests composed of plasters have been highlighted.

Gherasim valley, having its outlet in Vâlcele valley, has its origin on the Pleistocene piedmont, initially having a west-east direction and, encountering in its route Gherasim Hill and Nistoroaia Peak that have plasters in their axes, changes its direction gradually, towards the south. On this route, at west from Nistoroaia Peak, it reached to a harder layer, composed of plasters and freestones, it could not penetrate. The water taken over from its own basin found cracks in the layers upstream the plasters, infiltrated into the rocks and at present appear under the form of a Karstic intermittent spring, at the south of the natural levee, at an altitudinal difference from the sink-hole of 28 meters. These conditions allowed the formation of some forms of plaster relief, represented by a natural bridge, unique in Moldavia, doline, sink-hole, Karstic intermittent spring, lapiès or intermittent debit spring.

The evolution of the relief in the area was influenced by the presence of the natural levee, which protected the lands upstream, while, on Nistoroaia valley in the west vicinity, the free denudation determined the descent of the thalweg by about 25 m, with the corresponding extension of the adjacent versants.

Gherasim torrential valley is affected by active denudation processes, represented by the surface erosion in the entire basin, of active depth erosion on 30 % of the basin and by landslips, locally with failures, which have a weight of 74 %.

The relief identified in the researched area has scientific importance in order to highlight the forms of relief existing at the level of the country, have didactic significance because they are found on a restrained space and with a good accessibility and measures for the preservation, protection of the lands upstream the natural levee are imposed against the intense denudations, on vicinity.

It is necessary that it receive the status of protected area as geomorphologic site of national importance.

The preservation of these forms of relief can be achieved by measures referring to:

– stop of pasturage in the lower basin of Gherasim valley, the removal of knobs and the removal of subforest stand in order to bring the forest to the level of highforest;

– forestation of areas that are in unproductive use at present, with the

performance of works protecting the terrestrial area for lying fallow purposes;

– levelling works, surface drainage and over-seeding, for the slipped lands;

– concreted steps on the last 200 m upstream the sink-hole, for the preservation of balance, both for the versants and for the thalweg;

– the controlled discharge of pluvial waters, that are accumulating upstream the natural levee, having the primordial purpose of protecting the natural levee;

For the development of these lands for tourism purposes, it is necessary to be achieved:

– slab paths which ensure the circulation of tourists towards the natural levee, sink-hole, Karstic intermittent spring and the areas of lapis presence;

– the arrangement of drain channel for the waters on the inferior route of Nistoroaia valley and of the current spring, with a table and benches for the stops;

– periodical control for the maintenance of cleanness in the area;

– as mandatory activity in the schools of Târgu Ocna town, travels in the area are necessary, to know the travel interest or educational objectives.

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CONSIDERATIONS ON RECENT FREEZING PHENOMENA ON BISTRIŢA AND BISTRICIOARA RIVERS

Găman C.[1]

Key words: freezing phenomena, frazil slush, ice jam, ice cover.

Abstract. It is highly important to have a better knowledge of river systems during the seasons when air temperature drops below freezing point if we consider the difficulties posed to hydrotechnical exploitations and the destruction caused by floods (as a result of ice jam development). The article presents briefly some opinions and hypotheses various researchers have formulated over time on the genesis of ice formations on rivers. Moreover, the article includes several analyses of ice formations developed on the Bistriţa and Bistricioara rivers as wells as hazardous winter phenomena that may cause such ice formations, e.g., ice jams (ice dams). The development of winter-specific phenomena on the two rivers during the winter of 2011 - 2012 is illustrated in pictures, graphs, and maps taken or developed on the basis on data collected *in situ* during research.

Introduction

Starting from studies and research made by some hydrologists, hydro-technicians, climatologists, and geomorphologists (e.g., Ciaglic, 1965; Ciaglic *et al.*, 1975; Ciaglic, 1984; Ştefănache D., 2002, 2003; Păvăleanu 2003; Ştefănache D.,2007; Ciaglic, 2008, 2009; Rădoane M. *et al.*, 2008, 2009; Giurma *et al.*, 2010 and Ciaglic, 2010), we aim at contributing as much as possible to determining the specificity of the development of river-ice formations that pose questions, the causes leading to the occurrence of such phenomena, e.g., those during the winter of 1972-1973 on the Bistriţa River, namely of an ice jam considered "unique" in Romania and even in Europe, and their evolution over the following years. To this purpose, and having considered that there have been no surveys of both rivers for the same time interval, during the winter of 2011-2012, we conducted visits to

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various sectors of the River Bistriţa and its tributary Bistricioara, in order to take measurements of air temperature, water temperature in the river and to map the existing ice-formations.

Fig. 1 Measurements conducted on Bistricioara and Bistriţa Rivers, March and November 2012

The need to conduct measurements and observations at the same time was a prerequisite as Ciaglic V. (2008) had noticed that the development of the freezing phenomena on both rivers was almost identical. The same author (Ciaglic, 2008, 2009) appreciated that Bistricioara River could be considered a natural "laboratory" where solutions and procedures could be identified that, if applied to the River Bistriţa, may positively influence the development of ice jams while preventing their development. Practically, the procedures proposed modify the river-flow regime and, consequently, riverbed ice-formations as well as the massive frazil slush flow may be reduced significantly. Such flows constitute the main factor that causes ice jam formation at the 'tail' of the Izvoru Muntelui – Bicaz Reservoir.

The Area under Study

The River Bistriţa, originating in the Rodna Mountains (the North Group of the Oriental Carpatians), has the longest mountain sector (the Carpathians) of the rivers in Romania, i.e., 216 km, or two thirds of its total length. The sector undergoing analysis between its border on the Suceava County (downstream Broşteni, i.e., Borca) and the 'tail' (end) of the Izvoru Muntelui – Bicaz Reservoir.

The River Bistricioara, the main right tributary of the Moldavian Bistriţa River, crosses a medium-high mountain area belonging to the central group of the Oriental Carpathians. The river sector under study is limited on the upper side by the location called Capul Corbului (downstream the confluence with the Muncelul

Mare Creek, Harghita County), and on the lower side by the Izvoru Muntelui – Bicaz Reservoir.

Genesis of Ice Formations

Every winter, various ice formations develop on these rivers both on the surface and in mid- stream, depending on the physical, geographic, and weather-related factors. A brief presentation of the first hypotheses regarding the development of ice crystals or needles, river-bottom ice and frazil slush is to be found in *Hidrologia*, a book published by Constantinescu *et al*. (1956), which contains a presentation given below:

Gay Lussac, who formulated one of the first hypotheses, claimed that the development of *ice crystals* is possible only on the surface of water and then they are carried away into the entire liquid mass. When the ice crystals reach the river bottom, they are retained in the irregularities thereon and, due to successive gathering, they create crystallising nuclei around which the *bottom ice* develops. When the volume of the bottom ice reaches the limit at which its ascending force exceeds, the cohesion between the ice and the sub-layer it developed on, it detaches and rises to the surface of the water forming *frazil slush* ('*zai*' or '*inie*' = 'floating ice') (Figure 2).

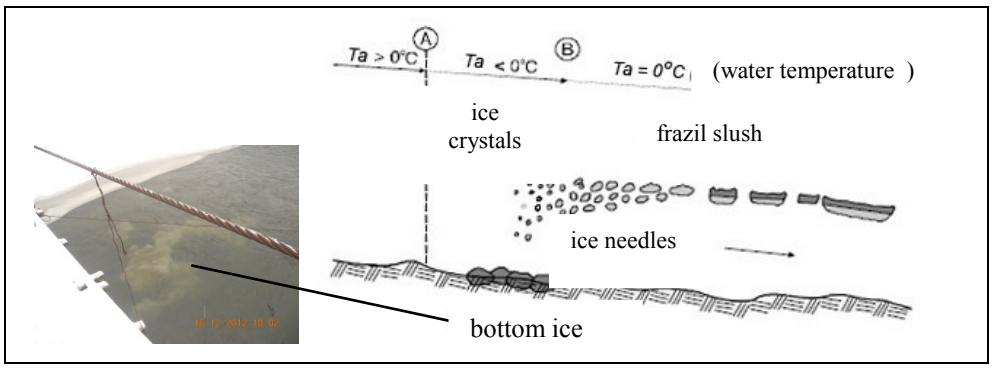

Figure 2 Various types of river ice formations (Beltaos et al., 2000).

Argo, Makaveev, and Altberg claim that the decisive factor causing the formation of various types of ice is the supercooling of water. In N. A. Zillerman's opinion, bottom ice can develop equally in the entire water mass.

While synthesising the hypotheses of the researchers cited above, Ciaglic *et al.* (2009) reaches the following conclusions:

- the supercooling of water in not sufficient enough to form the ice needles; for such needles to form, there is a need for freezing nuclei in the water mass and

low flow velocity (at the limit), as turbulence prevents the water temperature from dropping sharply;

- water supercooling occurs at very small readings below 0°C, i.e., hundredths of degrees, as demonstrated by the Altberg's experiment;
- in the case of river bottom ice formation, there should be a low water flow velocity, and the area, within a turbulent stream where water flows very slowly, should be on the bottom of the river;
- the very weak low velocity wind, as opposed to strong ones, favours the supercooling water process.

The same author considers that supercooling of water on the river bottom is due to the fact that the first ice needle formations, which are carried to the river bottom by turbulence, melt once they reach the slightly positive-temperature water mass. This process develops similarly to evaporation with heat consumption. The ice needles reaching this area later no longer melt but they accumulate and form river bottom ice.

Moreover, Ştefănache D. (2007), in the study on the "development of some hazardous hydrological phenomena," and Victor Sorocovschi, in *Hidrologia uscatului* (2010), present the development of the first ice formations, including shore ice, frazil pans, and ice cover (Figure 3):

- *shore ice* involves an advanced freezing process, which favours the development of a thin ice sheet in the low-velocity sectors. Shore ice looks like an ice sheet developed along either bank or both;

Shore ice, downstream the bridge | Ice covers with eyes, some 8 km from Chiril, Suceava county | Frazil slush drifting on the Bistriţa River upstream Holda, Suceava county

Fig. 3 Ice formations, covered with snow on the Bistriţa River, in winter 2011 – 2012

- *frazil pans* represent pieces of ice of various sizes and shapes that drift on the surface of water. In spring, the pans develop from the fragmentation of the ice cover when there is an raise of air temperature;
- *ice cover* is the steadiest formation of all winter phenomenon on rivers. The ice cover can develop both due to the advance of the shore ice along the banks

and to the frazil pans that get jammed where the riverbed narrows or in areas where the gradient varies. In case of very low air temperatures, on some low debit rivers, the river can freeze completely. Hydrometric units record this formation as *full freeze;*

- *discontinue ice cover or with 'eyes'* is encountered on high-velocity river sectors (rapids, meanders etc), having rich underground sources.

From the wide range of freeze-up phenomena that appear on rivers, **"ice jams"** are considered the most dangerous as they cause severe destruction and even claim casualties. This is why Ashton (1986) defines it as "*the most hazardous winter phenomenon on rivers*" – quoted in Maria Rădoane *et al*. (2008). The Romanian term "*zăpor*" (i.e., *ice jam*, English; *zator*, Russian; *embâcle*, Frech; *eisbarre*, German), defines the ice jams developing on rivers during winter. The blockage on the flow sector causes a fall of the water level downstream and a rise of the water level "behind" the ice jam (upstream). Energy builds up and acts in the body of the ice jam; hence, in case of rapid melting, the phenomenon can cause severe damages downstream.

Types of ice jams and their development

Depending on the time of the year when the phenomenon develops, two types of ice jams are distinguished, i.e., freeze-up and meltdown ones.

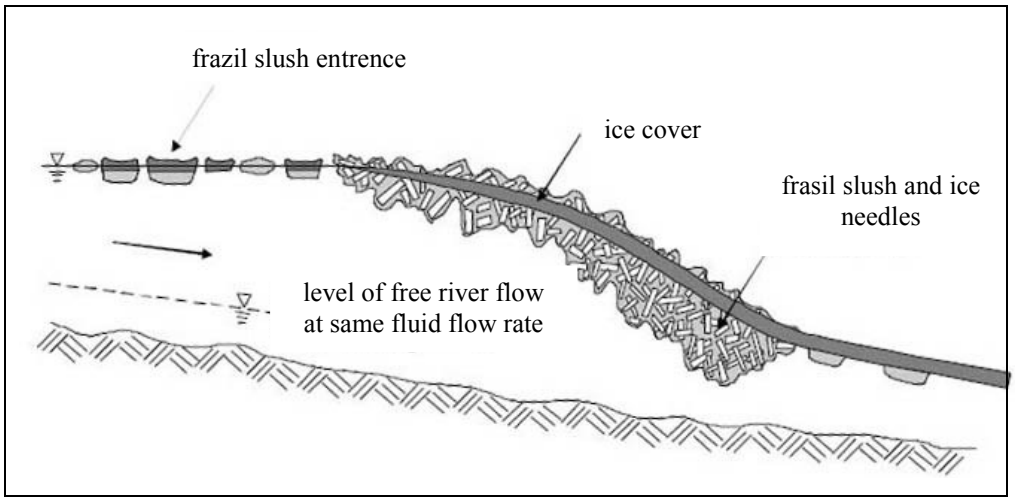

Fig. 4 Longitudinal cross section of a developing ice jam. The high level of the river water should be noted which was caused by the roughness and thickness of the ice jam (Beltaos et al., 2000).

Freeze-up ice jams develop during the occurrence and development of river freezing phenomena (beginning of winter). They are caused by frazil slush

gathering under the ice cover. The evolution and development of the ice jam can be seen in Figure 4.

Meltdown ice jams are caused by ice pans gathered in certain sectors because of a fragmenting ice jam whenever air temperature rises sharply. In the Bistriţa basin (upstream of Izvoru Muntelui – Bicaz Reservoir), the phenomenon is highly frequent on the upper sector (Depresiunea Dornelor down to Zugreni) and it has a lower frequency in the Zugreni – Crucea sector (Ştefănache, 2003, 2007; Surdeanu *et al*., 2005; Rădoane M. *et al*., 2009; Giurma and Ştefănache D., 2010). In the Crucea – Borca sector, these types of ice jams display a very low frequency, and downstream Borca there have been no records of such types of ice jams.

Ice jam upstream the 'tail' of Izvoru Muntelui – Bicaz Reservoir

After the development of the Izvoru Muntelui – Bicaz Reservoir, in downstream Borca sector a special type of ice jams began to develop. This type blocks the riverbed over long distances; sometimes exceeding 20 km, the frazil slush accumulations reach between 1 – 8 m thickness (Figure 5 a and b)).

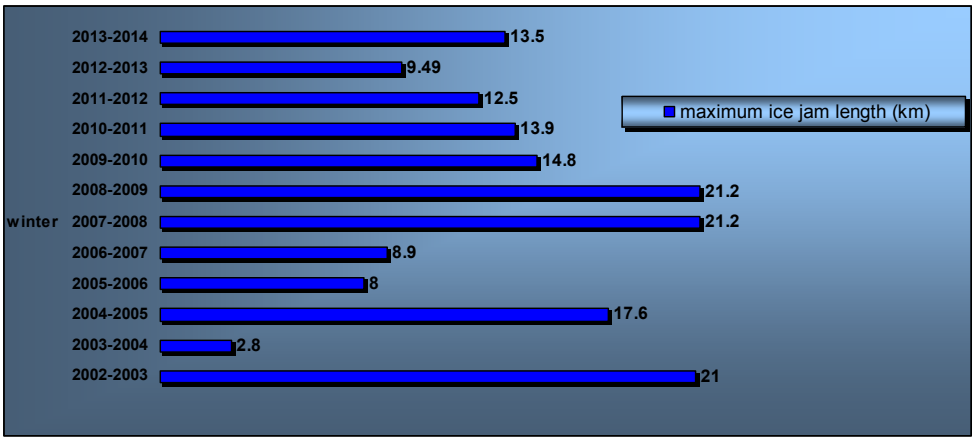

Figure 5 a) Variation of maximum length of the ice jam on the Bistriţa River (sector: 'tail' of the Izvoru Muntelui - Bicaz Reservoir up to the border on Suceava county), between 2002 – 2014 (Source: data processed by Neamt County Water Management System)

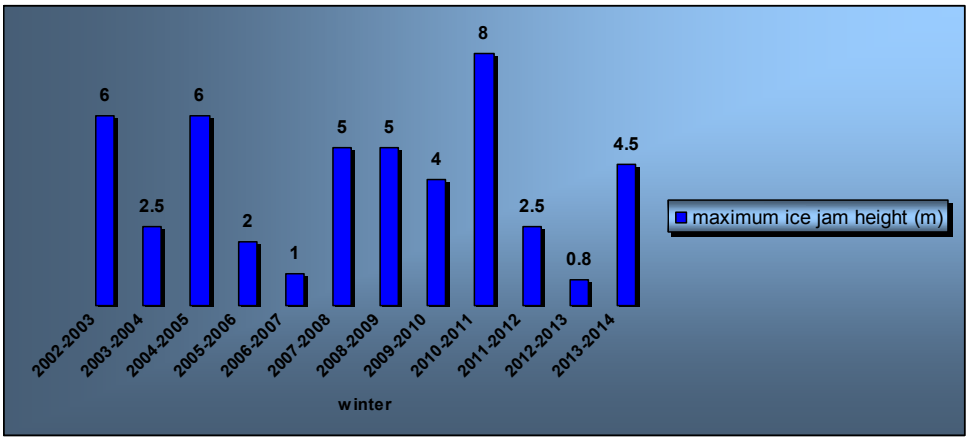

Figure 5. b) Variation of maximum thickness (height) of frazil slush (ice jam) on the Bistriţa River (sector: 'tail' of the Izvoru Muntelui – Bicaz Reservoir up to the border on Suceava county), between 2002-2014 (Source: data processed by Neamt County Water Management System)

The duration of the phenomenon ranged between 24 days (winter 1992 – 1993) and 110 days (winter 1995 – 1996) for the time interval 1972 – 2002, and for the interval 2002 – 2014, between 38 and 124 days (Figure 6).

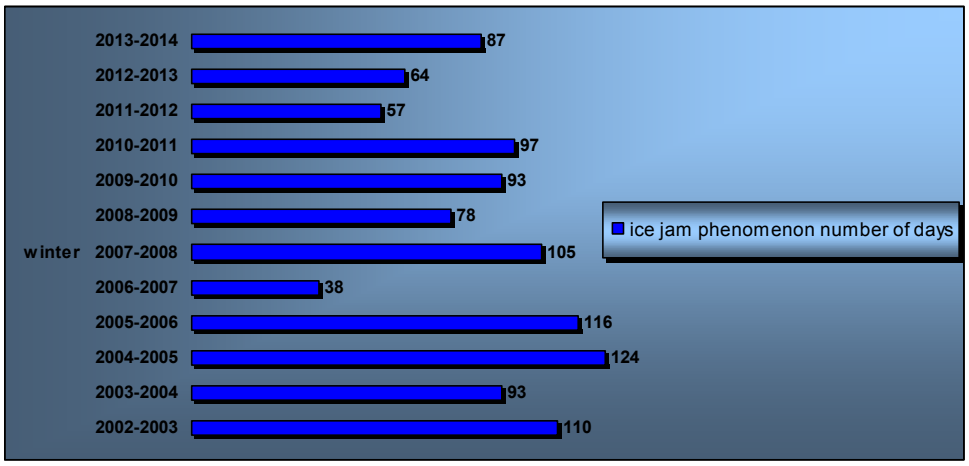

Figure 6. Evolution of the ice jam phenomenon on the Bistriţa River (sector: 'tail' of the Izvoru Muntelui –Bicaz Reservoir up to the border on Suceava county), between 2002 – 2014 (Source: data processed by Neamt County Water Management System)

As shown in the bar chart, over the last twelve years, the period when the ice jam phenomenon appeared displayed and uneven distribution depending on the weather conditions specific to each year. The average number of days for the period between 2002 and 2014 when ice jams were recorded was of 88 days.

An analysis of the three previous bar charts allows us to notice that the phenomena was more intense during winters when ice jams developed at short time intervals and exceeding the 88-day average. Hence, the maximum length of the ice jam on Bistriţa River upstream of the 'tail' of Izvoru Muntelui – Bicaz Reservoir exceeded the Frumosu hydrometric gauging unit, namely 12 km, and the maximum thickness of ice agglomerations was over 4.5 m. Exceptionally, during the winters of 2003 – 2004 and 2005 – 2006, the ice jam phenomenon was manifest for over 88 days, but with a relatively lower intensity.

This type of ice jam was noticed for the first time by Ciaglic *et al*. (1975). The authors state that the phenomenon undergoes two stages, i.e., the first stage *submersed*, when frazil slush carried by the river subducts the ice cover on the river for some distance. Therefore, the sector becomes obstructed due to the deposit of frazil slush on the bottom of the former riverbed inside the reservoir cuvette (Călugăreni area) and not by "juxtaposition" to the lower base of the ice layer (as it happens on rivers), wherefrom it extends gradually upstream through the riverbed, filling it and, quite often, bursting onto the banks as well – the *emersed stage* (Figure 7).

Figure 7. Manifestation of ice jam phenomenon on the Bistriţa River (emersed stage), in 2008, 2009

The hypotheses of the authors cited regarding the fact that the first blockage (ice jam) is generated from within the reservoir underneath the ice cover and gradually extends upstream were confirmed by personal observations conducted in March –April 2012. Once the ice cover melted at the 'tail' of the reservoir, we noticed that on the entire length of the Bistriţa River course, from Călugăreni to the Poiana Teiului viaduct, the riverbed was full of frazil slush containing sediments

and covered with some 8 – 14 cm-thick layer of mud, on top of which there were also pieces of ice (Figure 8).

Figure 8. Modified flow of the Bistriţa River in the Izvoru Muntelui – Bicaz Reservoir basin following the obstruction of the former river bed with frazil slush (submerged stage), March and April 2012.

Evolution of the ice jam phenomenon in the winter of 2011 - 2012

During the winter of 2011 – 2012, the first frazil slush agglomerations on Bistriţa River developed on the 21st November 2011, covering a length of 2.50 km, in the Topoliceni – Poiana Teiului reservoir sector, some 600 m upstream the Ruseni bridge, village of Galu, commune Poiana Teiului. The conditions favouring the occurrence of the ice jam phenomenon were as follows: flow of frazil slush since 18th November 2011 on some 30 – 40 % of the water surface, air temperature recorded at the Frumosu hydrometric gauging unit of – 6.5˚ C and ice cover upstream the Topoliceni dam. Ever since 2003, when the Topoliceni reservoir was put to service, a new base level on the Bistriţa River was created. The phenomenon manifested for two days, i.e., until the 23rd November, when on the sector between the Topoliceni dam and 700 m upstream Ruseni bridge, namely on a 2.50 km-length, the Bistriţa River displayed only 0.30-to-1.00m-thick shore ice. The air temperature recorded at the Frumosu hydrologic gauging unit was 0°C. At the 'tail' of Izvoru Muntelui – Bicaz reservoir, the first frazil slush agglomerations gathered on 27th January 2012. The hydrologic conditions were as follows:

- from the Poiana Largului viaduct until 200 m upstream Poiana Teiului ACH footbridge, on a 3.6 km-length, the Bistriţa river displayed frazil slush

agglomerations with a thickness ranging between 0.15 and 0.80 m, with eyes and melted canal on some 10 % of the sector length;

- there was shore ice at the Frumosu hydrologic gauging unit and frazil slush was floating on 60 % of the water surface (the level of Bistriţa river measured 53 cm, the debit – 7.05 mc/s, air temperature was -12.2°C and there was a 7 cm-thick snow layer;
- the water level in the reservoir measured 487.11 m (Ceahlău hydrologic gauging unit).

As shown in the *Level variation graph – Izvoru Muntelui Reservoir, 2012,* the date of the development of the ice cover on the reservoir (Ceahlău hydrologic gauging unit) coincides with the date the ice jam was developed at the 'tail' thereof (Figure 9).

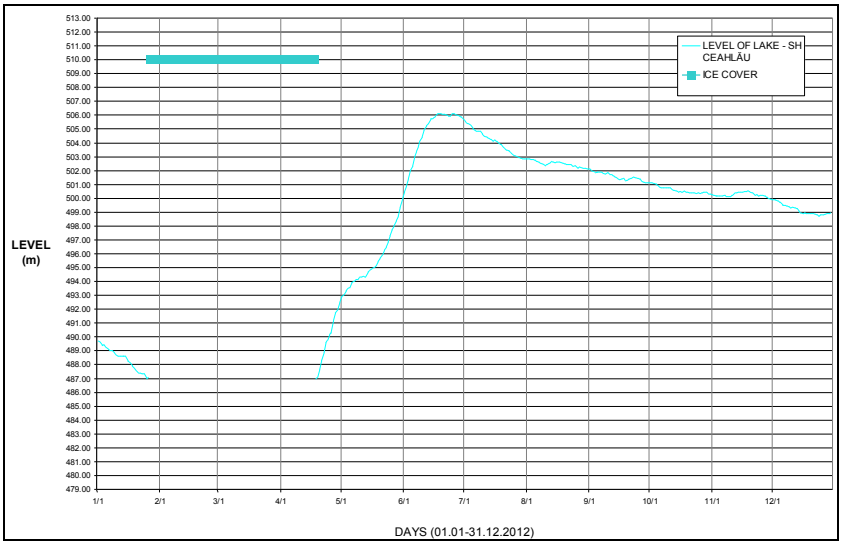

Figure 9. Variation of the level in the Izvoru Muntelui – Bicaz Reservoir, 01/01 – 31/12/2012 (Source: data processed by the Hydrological Unit Piatra Neamţ)

The Frumosu hydrologic gauging unit, located downstream the Frumosu bridge (at some 12.8 km from the Poiana Largului viaduct) the frazil slush agglomerations (ice jam) were present for 36 days, since 4th February to 10th March 2012 (Figure 10. a) and b)).

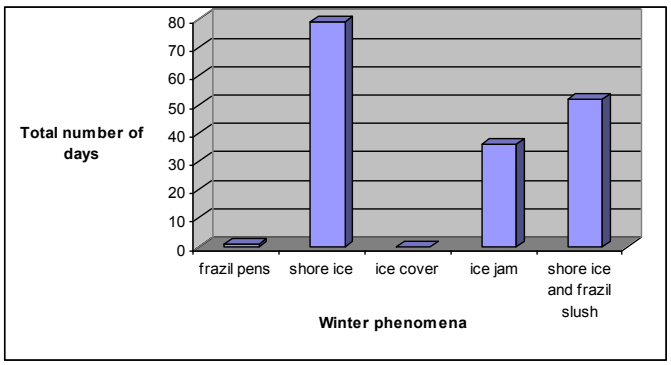

Figure 10. a) Quantitative evolution of winter phenomena on the Bistriţa River – Frumosu sector, 17/11/2011 – 24/03/2012 (Source: data processed by the Hydrological Unit Piatra Neamţ)

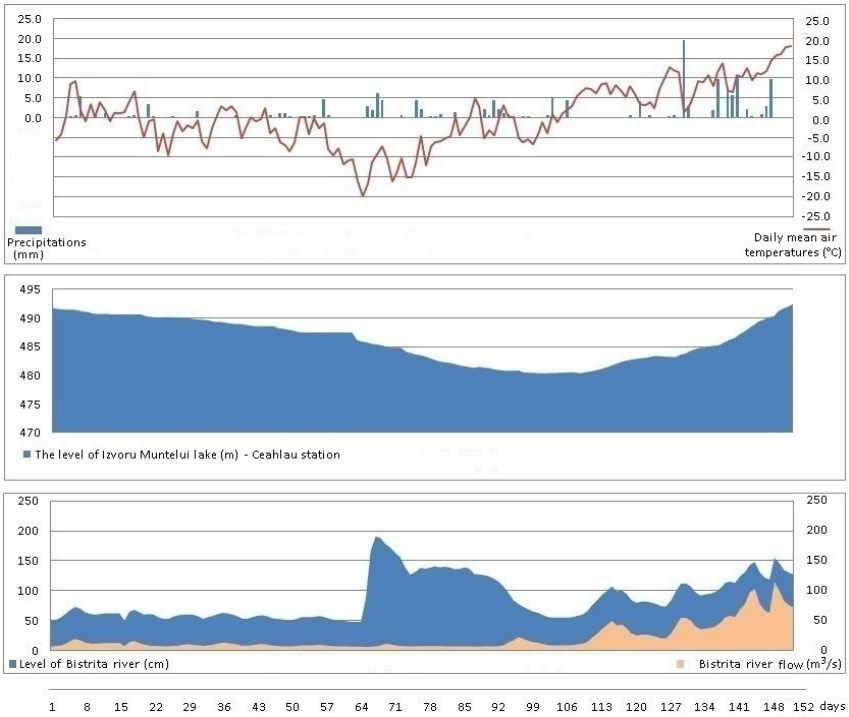

Figure 10. b) Variation of hydro-meteorological factors that influenced the ice jam at the Frumosu hydrometric unit – Bistriţa River, 1 December 2011 – 30 April 2012 (Source: data processed by the Hydrological Unit Piatra Neamţ)

Owing to the jam formed by frazil slush agglomeration, the daily level of the Bistriţei River – Frumosu sector – raised from 48 cm (02/02/2012) to 87 cm (03/02/2012), 167 cm (04/02/2012), and 191 cm (05/02/2012). Meanwhile, the debit of the river remained steady. At 07:00 a.m., on 5th February 2012, the hydrological status on the Bistriţa River, upstream the Izvoru Muntelui reservoir was as presented below:

- on the sector contained between the Poiana Largului viaduct and 0.2 km downstream the Ruseni bridge, on a 6.8-km-length, the river displayed frazil slush agglomerations whose thickness measured between 0.2 and 2.5 m;
- on the sector contained between the Săvineşti bridge and 0.4 km upstream the Frumosu bridge, on a 4.4-km-length, the river displayed frazil slush agglomerations whose thickness measured between 0.2 m and 1.0 m, with alternating eyes and a 1m-to-3m-wide melted canal on some 30 – 35 % of the sector length;
- from upstream. there was frazil slush floating on some 40% of the water surface; air temperature at Frumosu hydrologic gauging unit, Commune Farcaşa, measured -10.5.

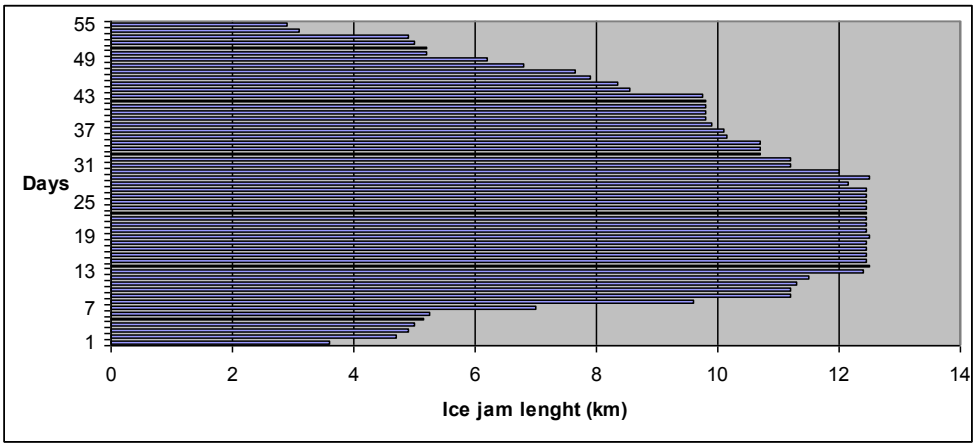

Figure 11. a) Variation of the length of frazil slush agglomerations (ice jam), upstream the 'tail' of Izvoru Muntelui – Bicaz Reservoir, between 27 January and 21 March 2012 (Source: data processed by the Hydrological Unit Piatra Neamţ)

Depending on the number of days and the intensity of the frazil slush flow (10% - 70% of the water surface), on lengths ranging between 3.60 km (27/01/2012) and 12.50 km (09, 14, and 24 February 2012), on the River Bistriţa, upstream the Izvoru Muntelui – Bicaz Reservoir, frazil slush agglomerations (ice

jam) developed alternating with eyes ranging between 0.15 and 2.50 m and a 1-to-5m-wide melted canal on 10 – 40 % of the sector length (Figure 11. a, b and c). Air temperature at Frumosu hydrometric unit was steadily below 0°C, except for 25 February, 19 and 20 March 2012, when positive readings were recorded (Figure 12).

Figure 11. b) Snow-covered frazil slush agglomerations on the Bistriţa River, upstream and downstream ('tail' of Topoliceni Reservoir) the Săvineşti – Poiana Teiului Bridge, on 16/02/2012

Figure 11. c) Snow-covered frazil slush agglomerations on the Bistriţa River, downstream Topoliceni Dam - commune Poiana Teiului, on 10/03/2012

Starting with 22nd March 2012, no ice jam phenomenon was recorded on the River Bistriţa, upstream the Izvoru Muntelui – Bicaz Reservoir, as there were no

more frazil slush flows, and air temperature was on the rise. Thus, in the winter of 2011 – 2012, the phenomenon was reported for a number of 57 days (2 days between 21st and 22nd November 2011 and 55 from 27th January to 21st March 2012).

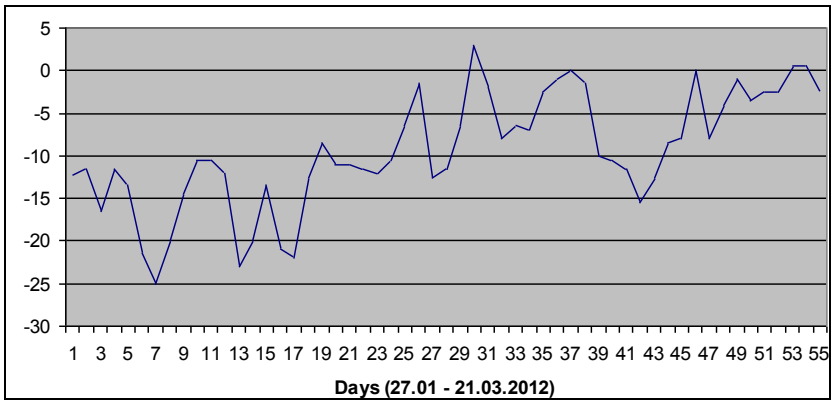

Figure 12. Air temperature variation at Frumosu hydrometric unit (daily measurements at 06.00 a.m.) (Source: data processed by the Hydrological Unit Piatra Neamţ)

Following the analysis of the air temperature variation graph at the Frumosu hydrometric unit, we can conclude that significant fluctuations of air temperature were recorded between 27th January and 21st March 2012, which influenced the development and the steadiness of frazil slush agglomerations (ice jams) on the River Bistriţa, upstream the Izvoru Muntelui – Bicaz Reservoir.

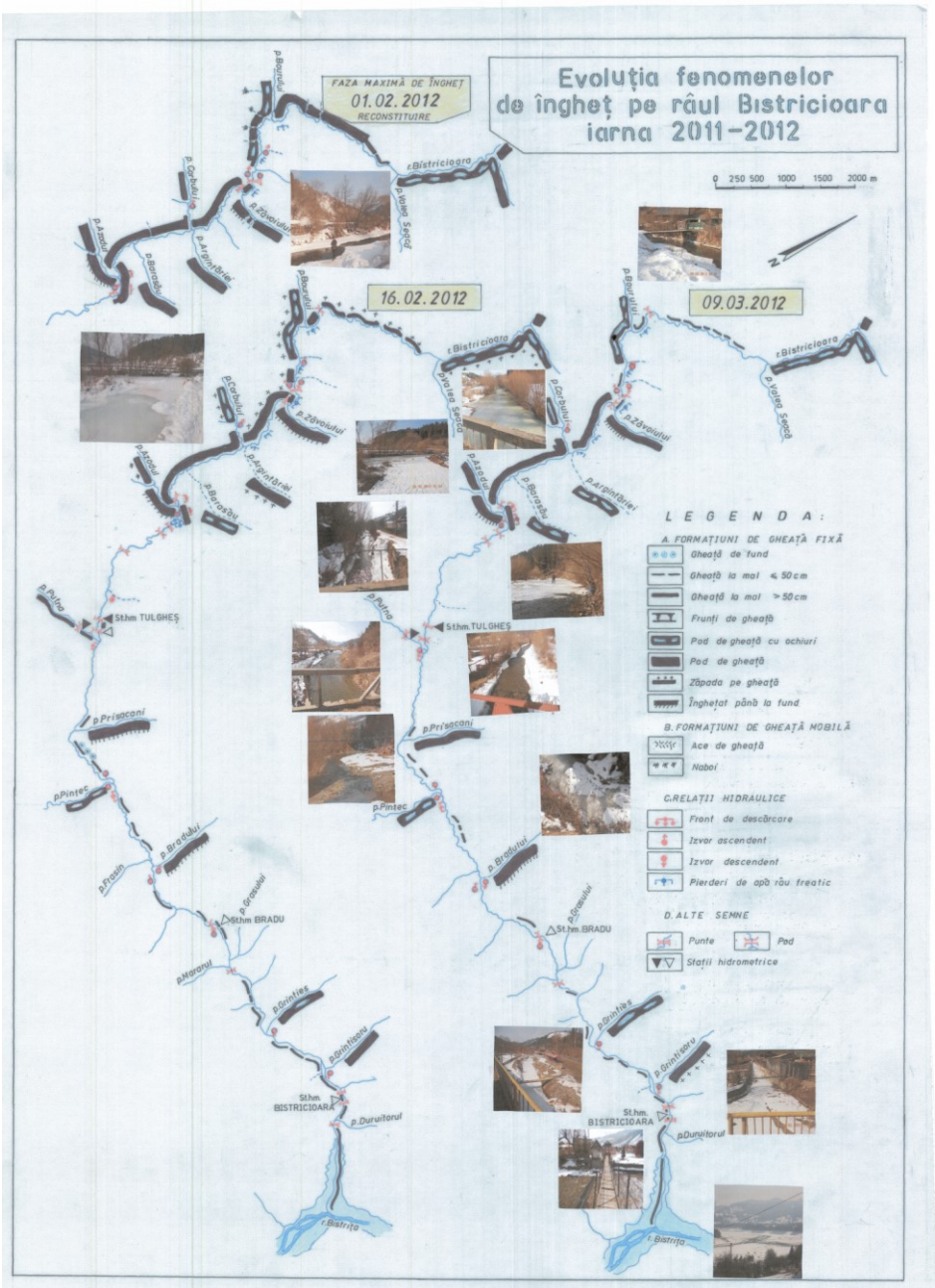

Figure 13. Freezing phenomena mapping on the Bistricioara River, winter 2011 - 2012

Conclusions

The causes of the ice jam development on the River Bistriţa, upstream the 'tail' of Izvoru Muntelui – Bicaz Reservoir, ice jams that significantly affect human settlements, defence works, infrastructure, farming areas, etc., are both *natural* (e.g., air temperature, wind, as well as the characteristics of the water flow in the river – turbulent or apparently laminar) and *antropic* (before the development of the Izvoru Muntelui – Bicaz Reservoir, there was no ice jam phenomenon recorded, although severe frazil slush and ice cover flow were frequently reported). Moreover, Ciaglic (1985) considers ice jam to be *atypical* as the frazil slush accumulation carried by the River Bistriţa develops on the bottom of the Izvorul Muntelui – Bicaz Reservoir and not by 'fusion' with the surface ice cover. A particular situation is encountered when the locks of the Topoliceni Dam – commune Poiana Teiului, are closed (the Poiana Teiului hydropower station is operating), and frazil slush gathers under the ice cover on the reservoir.

Notwithstanding, the occurrence on the Bistriţa and Bistricioara Rivers, under identical climatic conditions, of some sectors with well-developed ice formations as well as some river sectors in the immediate vicinity with poorly-developed or no ice formations proves that there are also some other generating factors, besides the meteorological and hydrological ones, that may strongly influence the development of freezing-up phenomena. The hydraulic relationships between the rivers and the areas they cross play an important role, hence the phenomena display a specific development sometimes manifested by a complete lack of ice due to the underground source.

This theory launched by Ciaglic (1965) was also confirmed by our personal observations conducted in the winter of 2011-2012, when measurements of water temperature were conducted in various areas and the phenomenon was mapped. Despite identical climatic, geological, and morphological conditions, in the small area covered by the Bistricioara River basin, the 35-to-40cm-thick ice cover spread over almost the entire surface of the river in the upper sector of the basin, upstream the confluence with Azod Creek. By comparison, downstream, the ice cover disappeared suddenly despite identical air temperature readings (Figure 14. a), b) and *Freezing phenomena mapping on the Bistricioara River, winter 2011 - 2012*).

Figure 14. a) Bistricioara downstream its confluence Azod Creek, March 2012

Ice cover with snow, Bistricioara River

Ice cover with snow, Azod Creek

Fig. 14. b) The Azod Creek at the confluence with Bistricioara, March 2012

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CONSIDERATIONS ON TEMPERATURE INVERSIONS IN THE LOWER TROPOSPHERE IN THE 2001-2002 COLD SEASON, SOUTH OF THE CARPATHIAN MOUNTAINS.

Bărcăcianu Florentina[1], Apostol Liviu[2]

Key words: troposphere, radiosounding, negative gradients, standardized temperature, termoisanomale, kriging, interpolation.

Abstract. Temperature inversions are characterized by negative vertical thermal gradients (Donciu, 1953, Ţâştea, 1965, Bogdan, 1971, Neacşa, Frimescu, 1981). The most frequent manifestation is in the depression areas because in addition to radiative cooling and better possibility to store cold air invasion, it also takes place the accumulation and of air flow of cold air due to gravity. The area south of the Carpathians, shows depression features, gaining titles like: carpathian-balkanic bucket (Bălescu, 1962), carpathian-balkanic sink (Ion-Bordei, N. 1988). In this space the inversions occupy the entire area, proof being the values from low altitude stations similar to those from mountain peaks, while the middle part of the slope remains wormer.

Introduction

Normally, the atmosphere is characterized by a decrease in temperature of the air proportional to the elevation, there are few cases where the temperature tends to rise in altitude, which is characterized by vertical thermal gradients that are negative or null (Apăvăloae et. al. 1994). The extra-Carpathian area shows climatic differences between north and south, set by latitude (Mihăilă, 2006, Machidon et al., 2012), and the higher areas, take the characteristics of the upper atmosphere, cooled by the increasing distance from the thermal source and increased effective radiation. Bellow the average altitude of the Carpathians, air circulation is strongly influenced by them , so blocking the eastern circulation results in outlining a negative thermal anomaly (Apostol, 1990, 2004) determining

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a stable vertical distribution of air with a thickness of 600-800m (Clima României, 2008).

The contribution of specific synoptic structures specific in the formation of these phenomena manifest themselves as some cold reservoirs in the winter season (Apostol, 2004, Ştefan, 2004, Rao et al., 2010), less intese than those in the Romanian Plain due to the heat generated by friction with the slopes. In any sinoptic situation, the carpathian chain restructures the baric field from the surface in the way that it favors cold air from northern Europe, from Moldova towards central Romanian Plain, where it takes place the ”circulations interference” (Bordei-Ion, N, Bordei-Ion, Ecaterina, 1981, 1984), and the amplification is due to relief and also due to the Coanda effect.

1. Methodology and data base

The data base used was made of data from radio sounding, complemented by temperatures recorded at 28 meteorological stations south of the romanian Carpathians. The termic values were recorded at 00 UTC and 12 UTC at Bucureşti-Băneasa aerological station and 1^{00} and 13^{00} for the rest of the meteorological stations.

Only 23 stations are included in the studied area, the rest being used for better results of the interpolation method, and also for a detailed calculation of the mean termal gradient of the 2001-2002 cold season.

Quantification of the reversed atmospheric stratification was done by analyzing temperatures, thermal gradients and standardized temperature, that suffered altitude and latitude corrections. Therefore, it was sought changes in temperature and negative gradients vertically over Bucharest. The increased diversity of radion sounding data, forced us to mediate the successive data recorded and to establish thermal values corresponding for each 100 m, up until 3000 m, above which the underlying active surface influence is insignificant.

The city, through its specific topoclimate, favors the registration of higher values in the lower layers than in free atmosphere, these conditions being favorable for the manifestations of local thermal inversions, so it was analyzed the horizontal thermal inversions in the area south of the Carpathians. The variables that prevent thermal value comparison and analysis, as well the researched phenomenon is represented by latitude and altitude, which were eliminated by reporting to the difference of 0,86°C/1 degree northern latitude (Apăvăloae et al, 1988, Apostol, 1990) and bringing thermal values to sea level, respectively 0 m, by applying horizontal thermal gradient of the 2001-2002 cold season.

Tab. 1. Meteorological stations located in the southern Carpathians

Meteorological stations	Altitude	Latitude
Bisoca	833	45,55
Campulung Muscel	679	45,28
Polovragi	532	45,18
Curtea de Arges	449	45,16
Pitesti	315	44,85
Targoviste	297	44,93
Patarlagele	289	45,31
Dragasani	282	44,67
Tg Jiu	206	45,03
Craiova	195	44,31
Ploiesti	178	44,95
Titu	160	44,65
Videle	109	44,28
Caracal	107	44,1
Rosiorii de Vede	103	44,1
Buzau	97	45,13
Drobeta T S	79	44,63
Alexandria	76	43,98
Calafat	63	43,98
Fetesti	61	44,37
Slobozia	52	44,55
Bechet	40	43,78
Zimnicea	34	43,66
Turnu Magurele	31	43,75
Oltenita	16	44,07

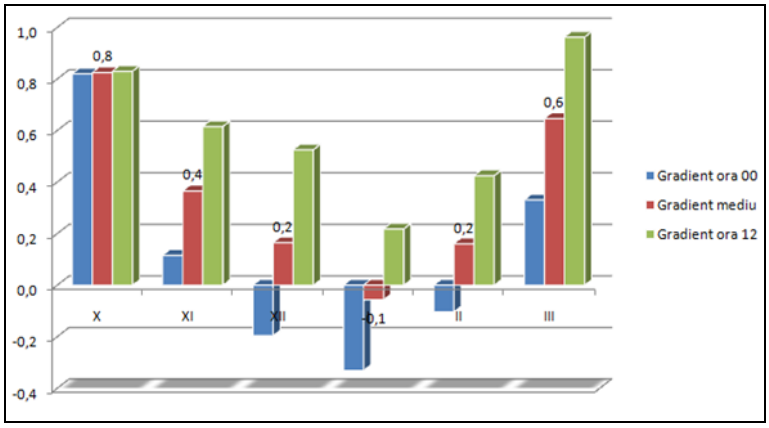

Fig. 1: The values of gradients featurea for cold season 2001-2002 over aerological station Bucureşti-Băneasa

The thermal gradient was calculated from values recorded at weather stations analyzed and altitude differences between them, respectively 0,39°C(see fig. 1). By applying the method of spatial interpolation of standardized values were obtained distribution maps of termoisonomals of the cold season characteristic of each month, for the two time periods studied, 0^{00} and 1^{00} and also 12^{00} and 13^{00}.

2. Results and discussion

The air stratification model south-east of Curvature Carpathians during winter (Apostol, 1986), with some modifications, can be generally applied to the entire area studied in this paper, for the winter season. A model on the distribution with altitude in the atmosphere for all Romania and in detail for the area south of Southern Carpathians was elaborated by Bâzâc Gh. in 1983. Observations relevant to the ground temperature distribution in the cold season were presented by Bacinschi et al, 1990; Bogdan Octavia, 1969, 1980, 2007; Bogdan, Iliescu, 1971, Clima României, 2008, with numerous references and studies on the thermal inversions phenomenon, analyzed on data from the meteorological stations from ground level south of the Southern Carpathians. The major role of the Southern Carpathians and the Curvature Carpathians in shaping the thermal characteristics of the regions south and south east, has been studied by Bordei-Ion, N. şi Bordei-Ion,

Ecaterina, 1988.

2.1. Analysis of temperatures in the lower troposphere above Bucureşti-Băneasa

Temperature decreases with altitude and in some cases is the opposite of the usual stratification and characterizes thermal inversions situations (fig. 2.). In this case, the downward trend of the temperature in the first 3000 m of the troposphere, the thermal inversions produces inflections of the evolving curves with large clusters in February-March in the case of the values at 00 and January-February in the case of the 12 values.

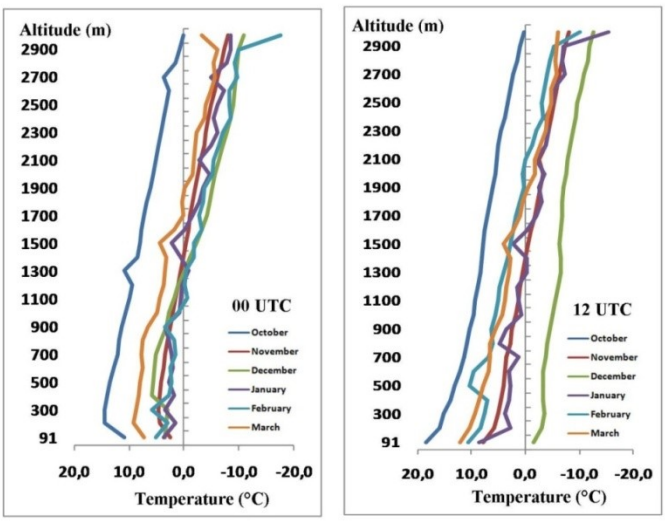

Fig.2.Distribution of cold season 2001-2002 average temperatures, at 00 UTC and 12 UTC over Bucureşti-Băneasa aerological stations

The high variability of the thermal regime in altitude does not reflect or confirm the presence of thermal inversions, these are more clear by analyzing statistical and mathematical the negative thermal gradients.In case of the values registered during night, those characteristic for the altitudinal interval of 200 - 800 m exceed the temperature at ground level (91 m). The downward trend is interrupted by the values characteristics for intervals 2000-2200 m and 2600 and 2800 m. Values at noon (12 UTC) shows a maximum at ground level, due to solar radiation and the variations are much lower than the nocturnal, the isotherm of 0°C placing it in both observation cases around the altitude of 1600 m.

2.2. Analysis of negative gradients in the lower troposphere above Bucureşti-Băneasa

Concentration of thermal inversions respectively the negative gradients is achieved mainly by the end of the cold season in case of data from 00 hour, with a gap towards mid-season for those at noon.

The maximum frequency occurred for values at 00 below 200 m altitude, a main interval with high frequency ranges between 91 and 600 m and the secondary between 1100 and 1600. In the case of the noon records, the maximum frequency is recorded in the 300-600 m interval and intervals with high frequency but with

small thickness occur at 1200-1600, 1900-2100 and 2400 m, the increased variability being associated to diurnal values (see tab.2).

In 2001-2002 cold season maximum frequency of over 70 % occur bellow 400 m in all six months analyzed and in the interval 300-500 m for those at 12. At night occurs temperature inversions at ground level and by day through strong insolation at ground level these remain only in upper levels.

3.3. Correlation between inversions recorded in the free atmosphere with those at ground level, south of the Carpathians

Applying the Pearson correlations between monthly mean values recorded at same heights as those of the meteorological stations, led to the making of some hypotheses, according to which we can state there is a similar trend between the free atmosphere and temperatures from the station level. Very high correlation characterizes the 150-300 m level and above 400 m the correlation is weak, except for altitudes above 2500 m where the correlation increases, reflecting the uniformity of weather and climatic conditions of the Carpathian Mountains.

For the correlation between temperature values recorded at noon, theese are very high of more than 0,86°C, with the mention that under 100 m the coefficient has the lowest values due to the differential heating of the underlying active surface and also in the interval between 300 and 700 m, where it still persist the inverse thermal stratification. Above this altitude the correlation coefficient values are high.

Tab.2. Relative frequency of thermal inversions in cold season 2001-2002 above the upper-air station Bucureşti-Băneasa

00 UTC	X	XI	XII	I	II	III	12 UTC	X	XI	XII	I	II	III
altitude (m)	relative frequency (%)						altitude (m)	relative frequency (%)					
91	81	53	35	55	62	73	91	6	3	3	16	17	13
200	71	47	35	68	72	60	200	0	0	6	26	3	3
300	45	37	35	55	52	40	300	0	3	16	39	7	0
400	10	27	42	48	34	17	400	0	13	35	61	21	7
500	16	17	39	45	28	3	500	0	20	35	42	41	10
600	3	13	19	35	21	7	600	3	30	29	32	24	3
700	10	17	3	32	28	7	700	6	27	19	23	17	3
800	13	7	6	13	10	7	800	10	3	16	23	10	17
900	0	17	3	13	3	7	900	3	10	16	10	14	13
1000	3	10	6	10	7	0	1000	6	7	13	16	10	10
1100	6	7	0	16	3	3	1100	10	13	10	23	14	0
1200	19	10	0	13	3	3	1200	13	10	3	19	7	3
1300	6	10	3	32	3	0	1300	13	13	6	23	3	10
1400	6	7	6	26	10	3	1400	16	10	13	16	10	10
1500	6	7	26	16	10	0	1500	10	10	29	13	17	7
1600	23	17	13	6	7	3	1600	13	10	19	10	3	17
1700	19	20	13	6	10	10	1700	10	3	29	10	7	17
1800	0	20	10	0	10	7	1800	6	3	23	10	7	3
1900	13	10	16	6	7	0	1900	6	3	16	13	3	10
2000	10	10	16	6	7	3	2000	10	13	13	23	0	10
2100	6	3	13	3	7	3	2100	10	17	16	19	7	7
2200	6	7	16	6	7	3	2200	10	17	6	13	3	0
2300	6	13	3	3	3	13	2300	10	10	6	19	3	13
2400	3	10	6	6	10	7	2400	0	7	13	19	3	10
2500	6	3	3	16	10	7	2500	10	13	6	16	14	10
2600	10	7	6	6	14	7	2600	10	7	0	10	3	3
2700	10	3	10	6	7	7	2700	6	10	3	6	0	3
2800	6	0	10	6	3	3	2800	0	7	0	0	3	3
2900	6	3	6	16	7	7	2900	0	7	6	0	3	7
3000	3	3	10	10	0	0	3000	6	7	6	0	7	10

3.4. Standardized temperatures - applying latitude and altitude corrections. South of the Carpathians it were eliminated the differences caused by latitude and altitude, namely modifying temperature values and level them to the corresponding values for 0 m and 45° 00´00″. Use of temperature values from analyzed stations was conducted with the aim of a better interpolation, the values of the stations inside the studied area being insufficient and irrelevant.

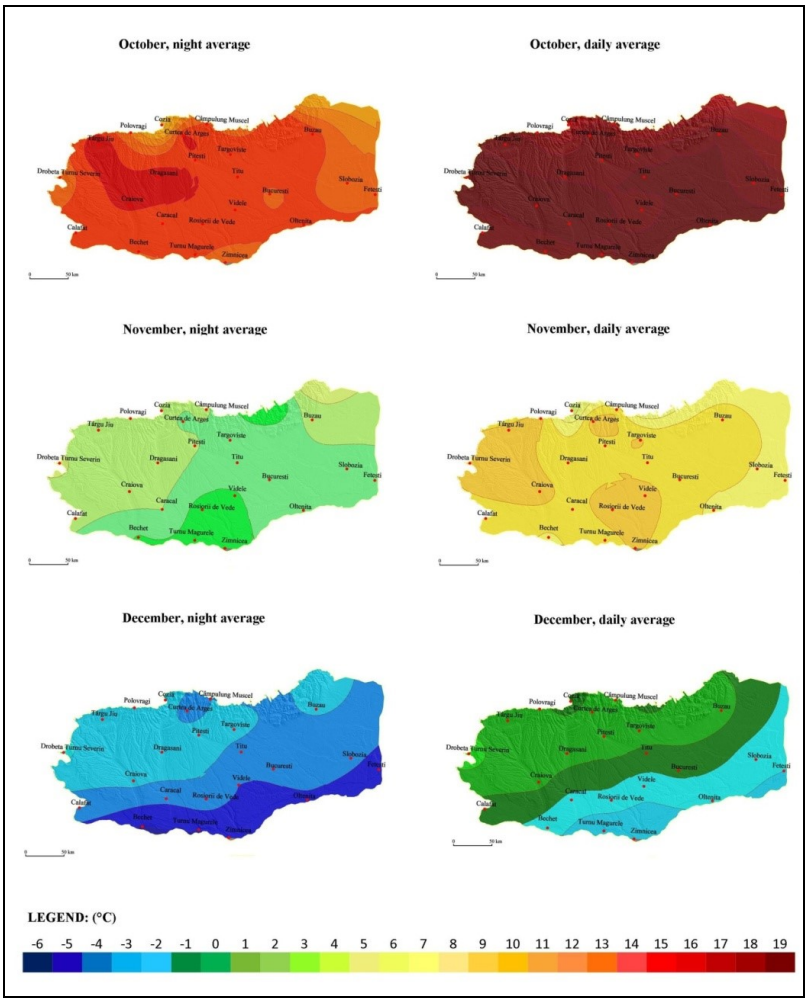

Fig.3. Spatial distribution of spatial distribution of October, November and December termoisanomales in the 2001-2002 cold season, south of the Carpathian mountains

The latitude corrections were performed according to the thermal horizontal gradient for the temperate climate area of northern hemisphere, 0,86°C/1°lat, the extremes being 45°55´ (Bisoca meteorological station) and 43°66´ (Zimnicea meteorological station), the corrections ranging between +0,47°C and -1,15°C. Temperature differences caused by altitude were corrected by applying the average thermal gradient of the 2001-2002 cold season, computed between all stations in the study area, respectively 0,39°C. Corrections were between the values of + 8.8 ° C for the meteorological station at Omu Peak and 0.52°C for the Braila.

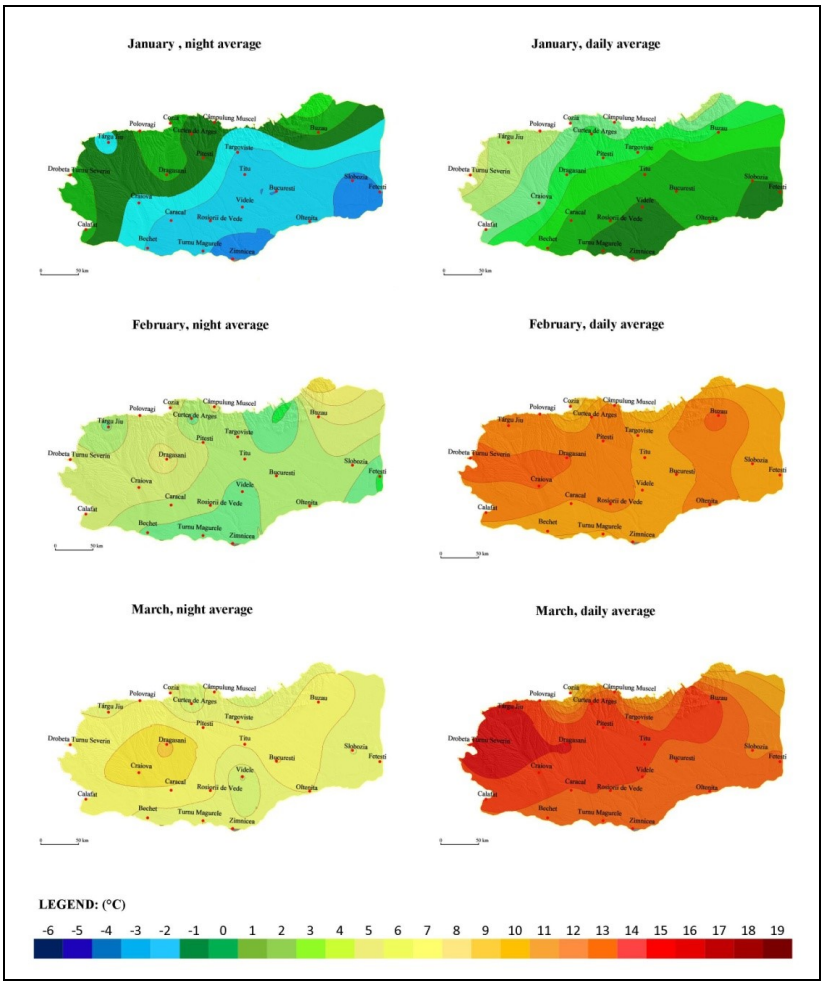

Fig. 4. Spatial distribution of spatial distribution of January, February and March termoisanomales in the 2001-2002 cold season, south of the Carpathian mountains

The results obtained by applying the latitude and altitude corrections were used to perform spatial interpolation (ordinary kriging), resulting in 12 maps(see fig. 3 and 4), classified by applying spatial simulation languages with the spatial distribution of thermoisonomals characteristic for each month of the 2001-2002 cold season for the observation intervals 00 and 1 and also for 12 and 13.

Conclusions

This study is useful in that it underlies many results obtained from ground data and gives some explanationson on the characteristics of thermal inversions in this area and their genesis.

Considerations regarding thermal statifications in altitude are of a real use in analyzing the air pollution phenomena (Haagen, 1959; Apostol, Pîrvulescu, 1988; Apăvăloae, Apostol, 1995), analysis required for the entire lower atmosphere, as in the studied area are many cities, among them Bucharest, industrial platforms, intense car traffic, and air pollution is a current issue.

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SUITABILITY OF WIND POTENTIAL IN SOME AREAS OF CENTRAL MOLDAVIAN PLATEAU

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Key words: wind potential, Central Moldavian Plateau, Huntsberger relation, statistic methods

Abstract. In the contemporary period, the most important element in sustaining and developing the society, under all its aspects, is represented by energy. Due to the fact that in society consumption is increasing, the actual preoccupation is to reduce the energy consumption and also to find clean, alternative sources to produce energy. The theme of this article is directed towards the concepts of increased availability and energetic independency and concerns estimations over the wind potential in certain areas of Central Moldavian Plateau. For this purpose there were analyzed genetic factors of the wind in the analyzed area and those parameters of wind speed, useful to the justification of the wind potential study. The obtained results confirm the fact that in Central Moldavian Plateau, in many areas, especially those of high altitude, are favorable conditions to use wind energy. Along with the remoteness from the Eastern Carpathians and the proximity of the Black Sea, the conditions become more and more favorable. Unfortunately, the lack of meteorological stations on the top of hills (besides the Barnova station, situated in the woods). Increased wind speed in the meaning of what was stated, was approved only on high valleys and upper terraces in the main valleys, especially on the Prut.

Introduction

The speed of wind is determined by general circulation of atmosphere and active surface characteristics, especially landscape. The major landscape from the studied are and of the surrounding areas, as well as in local landscape, influences the speed of wind especially by altitude, but also by the position on tops, slopes or valleys, morphology, the presence of localities, woods etc.

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The suitability of wind potential in this area was confirmed by numerous studies which individualized among areas with favorable wind potential, the tops of high mountains, especially those from the Eastern Carpathians and the Curvature Carpathians, Moldavian Plateau, Baragan, Dobrogea and Western Plains. Among these, the most favorable conditions are gathered in Dobrogea and Barlad Plateau. The suitability of the studied area for using electric energy is confirmed by using, in the past, widely, in this area, of windmills (Patrichi, Gugiuman, 1983)

Studies about wind energy potential in Romania, made by meteorologists and climatologists, most of them from the Meteorological Institute, belong to several stages. The first, including 7 and 8 decades of the last century, which correspond to the plenary development stage of Romanian climatology, and studies respond mostly to general goals regarding the knowledge of some applied climatology aspects and some hypothetical intentions of recovery. Studies are about wind characteristics in several areas (Patrichi et al, 1965; Patrichi, 1971 etc), the most important being those of national level (Cristodor et al, 1966; Stoenescu et al, 1967; Ţîştea et al 1976; Neacşa, 1979 etc). The second stage, the 9th decade of the last century was the result of an acute requirement, Romania, in the conditions of an oversized and intensive industry, could no longer ensure the necessary of energy from own conventional sources, and the financial resources for importation were nonexistent. We mention for this period fundamental research studies concerning the wind characteristics (Bâzâc, 1984; Voicu, 1984; Voicu et al, 1984; Frimescu et al etc), or for different regions (Bordei-Ion et al, 1984 etc). It are remarkable the studies of the team from Pângăraţi Resort, approaching methodological issues and analysis of the wind potential in Moldavia (Apăvăloae et al, 1985, a şi b; Apostol et al, 1985; Apăvăloae et al 1986). The last stage, from 1990 until today is characterized by some value synthesis regarding the wind characteristics in Romania (Soare, 2008), in different regions of the country, but especially by studies of the wind potential in Romania (Ţuinea et al, 1992), Moldavia, (Rusan, 2010) and other regions (Apostol, 2004).

The studied area includes several representative areas from the Central Moldavian Plateau: the Western high area, by analyzing the data from the meteorological station Plopana; the valleys from the western plateau; with general orientation north-west – south-east and west-east, represented by Negresti station; the main valleys, wider, from the center of the area are represented by the Vaslui meteorological station and Prut's Passage, by the Huşi meteorological station. The location of the national meteorological network, does not have unfortunately, presently any top station in Moldavia, until the altitude of 1900 m (Barnova station not being representative for analyzing the wind potential, being situated in the woods). Therefore the areas with the biggest wind energy from Central Moldavian

Plateau are not covered in our analysis, the nonexistent background data for wind energy in these areas being private so inaccessible.

For analyzing the limits of the studies areas and landscape conditions with influence over the wind energy were used bibliographic database. (Băcăuanu et al, 1980; Patriche, 2005 etc).

An important characteristic of the speed of wind is **average energetic speed**, which represents summing the speeds of active wind, which is >3m/s. to be able to correlate it with the power of wind turbines, the energetic speed must be used on stages of value. From most of the works on this regard, we can conclude that the efficiency of wind turbines, namely that their productivity depends on the speed and duration of the wind, but mostly on the presence, even in moderated values, of higher classes of wind, boosted values and location suitability.

1. *Data and methods*

Hereinafter, we will analyze the suitability for using wind energy in the mentioned areas from the Central Moldavian Plateau, by specific ways of approach. The old climatic data prior 1972 are accessible in climatic yearbooks, but unfortunately for a more thorough study of the wind, after 1972, there are restrictions in the climatic background data in the national meteorological network, the climatic data being accessible only partially and only from the stations in the international flux.

The background data used in this article is represented by series of 11 years for 3 stations (Plopana, Vaslui, Husi) and a series of 8 years for the Negresti meteorological station. The period for which the study was made is 1965-1975, respectively 1965-1972 and was chosen this period because of the fact that after 1960 the stations suffered changes of the observation program and in some cases of location (tab.1). The periods of observation are representative as number of years for this parameter of the wind, speed (Kostin, Pokrovskaia, 1964).

Tab. 1. Altitude and average wind speed for used meteorological stations

Station	**Altitude (m)**	**Medium speed (m/s)**
Plopana	230	4.9
Negresti	134	4.2
Vaslui	117	3.3
Husi	98	3.8

The authors of the previous studies used, generally, classical methods, comparative studies, using determination formulas of kinetic energy, but most

often using values of the average speed of the wind, annual, monthly and mostly monthly and annual for observation hours.

For processing the data, along classical methods of exposure of data graphical with the help of Excel program, there were used statistical methods by which it was synthesized the situation of wind frequency with certain speeds at the 4 meteorological stations.

To express the distribution of frequencies of quantitative variables – wind speeds, were used the statistic class by which it is revealed a subdivision of the variation field of the variable (wind speed), having as characteristics the inferior limit, respectively the superior limit. Grouping in classes of frequencies, is extremely important because it depends the rightness of the subsequent developments and exactness of the obtained results. To obtain these we used *Huntsberger relation*, with the formula for calculating $k = 1 + 3.332 * \log(n)$ where k = the number of classes, and n = the total number of values from the series. To establish the class limits, the most used progressions are arithmetic, geometric and squared progression. In this case was used arithmetic progression. Once the number of classes was found, it was calculated the size of the interval by the relation of H. D. Sturges, $l = \frac{x_{\max} - x_{\min}}{1 + 3{,}332 \log n}$. It resulted 10 classes of frequencies, with a size of the interval of 0.66, between the absolute minimal value and the absolute maximal value, the differences and amplitudes being constant.

2. Results

2.1 Suitability at a annual level

In the next section it will be presented the results obtained from the study of these characteristics of the wind in some regions from the Central Moldavian Plateau. It were presented the linear trends for the 4 studied stations, from west to east Plopana, Negresti, Vaslui and Husi (fig.1,2). The decreasing of the average wind speeds in the studied area happen from west to east, once the decreased altitude, with one exception, Husi station, were it is registered a slightly elevated speed from the Vaslui station.

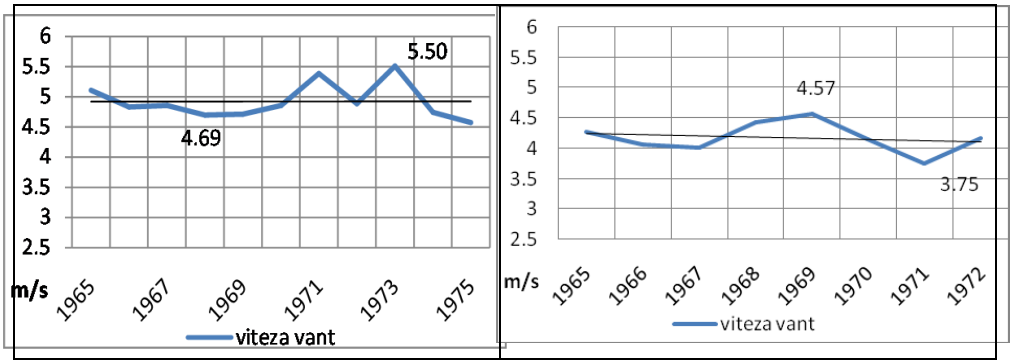

Fig.1. Linear trend of the wind speed at Plopana (left)and Negresti (right), (1965-1975)

Although the altitude values decrease from west to east and the Huși station is located at the lowest altitude, here, because of channeling the air masses on the Prut's Passage, the tendency of the wind speed is to increase, compared with the other 3 stations where it is registered a stationary or declining (Negrești and Vaslui).

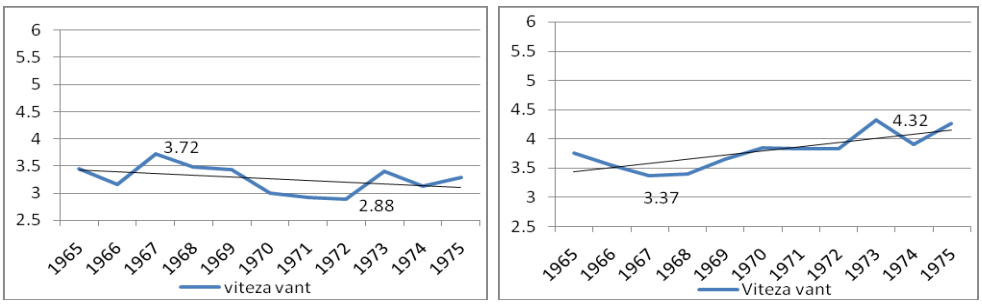

Fig. 2. Linear trend of the wind speed at Vaslui station (1965-1975) (left)Linear trend of the wind speed at Huși station (1965-1975) (right)

To establish the link between altitude and wind speed values it was calculated the coefficient of correlation. It is known that the speed of wind increases directly proportionally with altitude, therefore was analyzed in comparison, at the 4 stations the average wind speeds, correlated to the altitude of the location (fig. 3).

As you can see in fig.3, the average speed of the wind increases proportionally with altitude, exception being the Husi station where it is registered a higher value, which is observed in the coefficient R^2.

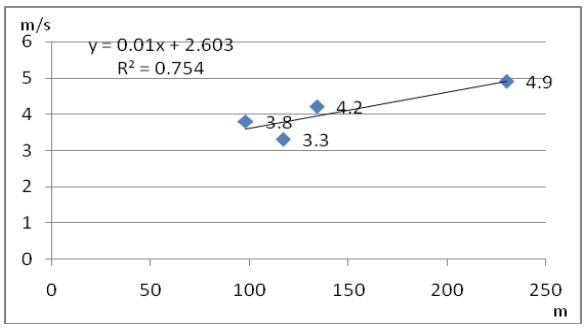

Fig.3. Altitude - wind speed correlation for used stations (1965-1975)

The closer to 1 is the value of the correlation coefficient R^2, the stronger the correlation between the two elements is. The value of R^2 which characterizes the correlation between the 4 stations is 0,754 and when R^2 is between 0,75 and 1, it presents a strong correlation, so this case presents a valid correlation, according to the idea of increasing the speed of wind in relation to altitude. Further it was realized the effective study of the suitability of energetic wind potential in the areas of the four stations from the Central Moldavian Plateau. It were analyzed frequencies classes of wind speed to determine the suitability of energetic wind potential, on the base of the number of frequent cases in the region of Plopana station. During the studied period, at the Plopana station the average speed is maintained constant, it are not registered but two major oscillations in the years 1971 and 1973 (Fig.1).

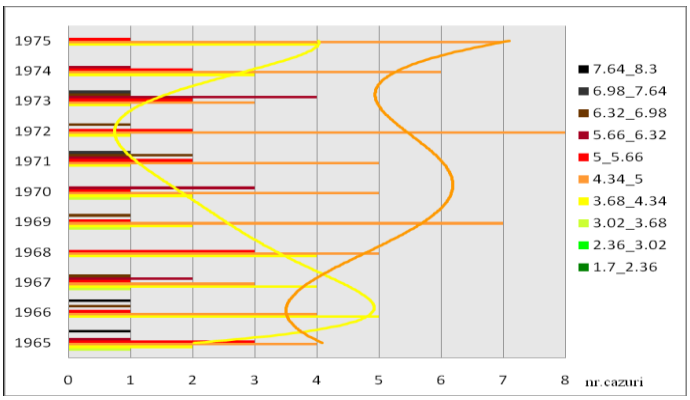

Fig. 4. Annual frequency of wind speed values at Plopana station (1965-1975)

The decreased variability and major values of the wind speed are the main characteristics of high wind performance, and at Plopana was registered the highest

values of average wind speed as well as a small oscillation over the years. In 1972 was the maximum number of cases for the value class of 4.34 - 5 m/s, which represents the year with the highest potential, with average speeds of the wind until 5m/s. The highest frequency was registered for the values class of 4.34 and 5 m/s, with a multiannual average of 5,2 cases, followed by the values class 3.68-4.34. according to these values and considering that over the years, according to the polynomial trend, the main values classes succeed, at Plopana station was registered a high potential of producing wind energy, the multiannual average speed being 4,9 m/s.

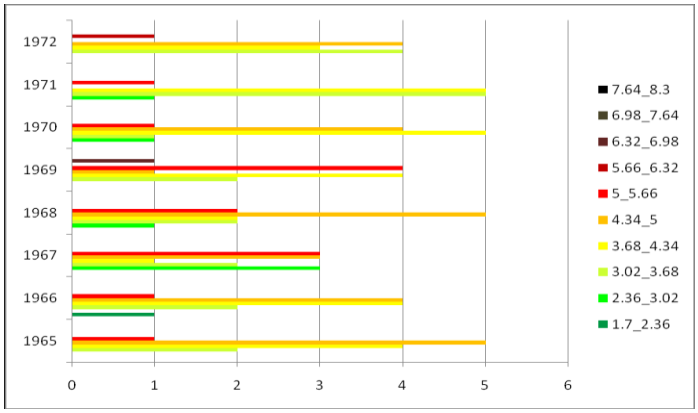

Fig.5. Annual frequency of wind speed values at Negreşti station (1965-1972)

For Negresti station, the speed of wind had an uneven character, with a general trend similar to that of Plopana station, but with a smaller number of cases, so a more pronounced variability, which decreases the wind performance. (Fig. 5).

Analyzing the value class of the speed of wind, we observe that it mainly fits in the value classes of 3.68-4.34m/s and 4.34 - 5 m/s. Even though it presents the same main value classes as in Plopana, the suitability is decreased because the wind speed presented a higher variability (more classes, but with smaller values) being a negative aspect for producing wind energy. According to the distribution of the speed and variability of the wind at an annual level, Negresti station presents a good energetic potential, inferior to that of Plopana station with a multiannual average of 4,2 m/s.

Frequency classes for Vaslui station present much smaller speeds of the wind comparative to the two stations presented previously (fig.6). The most frequent cases are those with speed between 2.36 – 3.02m/s and 3.02 - 3.68m/s. The maximum frequency is of the class of value between 2.36 and 3.02m/s, with a value of the multiannual average speed of 3,3 m/s, a speed for which wind turbines

of wide usage are not sufficient. Being given the small values of the wind speed the energetic wind potential is low, recommended for this area is the usage of wind turbines of low power, maximum 500W, which was the cut-in speed of 2/2m/s, being used only for domestic usage and in on-grid system.

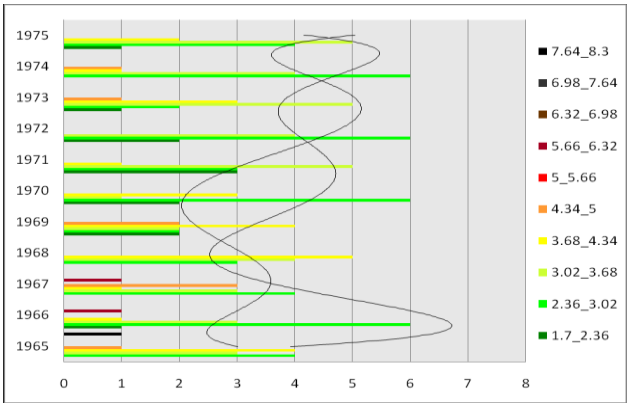

Fig. 6. Annual frequency of wind speed values at Vaslui station (1965-1975)

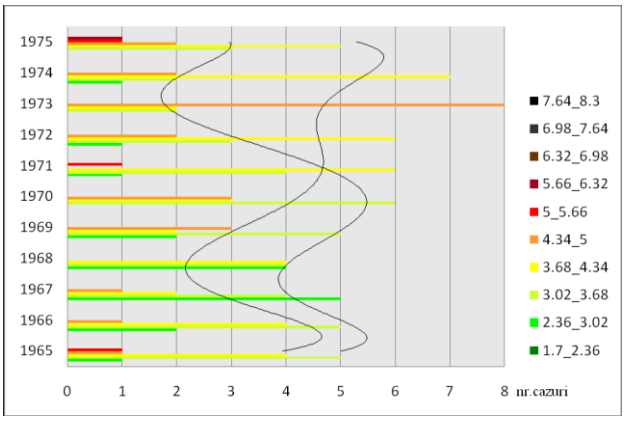

Fig.7. Annual frequency of wind speed values at Huși station (1965-1975)

At Husi station (fig.7) the speed of wind registers an increase towards the final of the decade, an increase that is sustained both from a linear trend (fig.2) as well as from a trend of the frequency of the values classes. The main classes are with values between 3,02-3,68m/s and 3,68-4,34m/s. In the first part of the decade is prevalent the class of values between 3,02-3,68m/s which has a decreasing trend and in the second part of the decade prevalent is the values class 3,68-4,34 m/s which presents an increasing trend. The energetic potential of Husi station is

average but increasing because of the speed of wind which has a positive trend and can be valued due to the minimal registered speed of 3 m/s – necessary for triggering the wind turbine, the multiannual average speed being 3,8 m/s. The wind turbines which are according to the registered speed at Husi station, are those of maximum 5 Kw, which can produce at a speed of minimum 3 m/s aprox. 2000Kwh/year.

2.2 The suitability at a monthly level

One aspect of a major importance of the suitability is the evolution at the monthly level, because over the year the wind regime varies. The trend of the wind speed is similar for all four stations, with a minimum in the warm season and a maximum in the cold season (fig. 8).

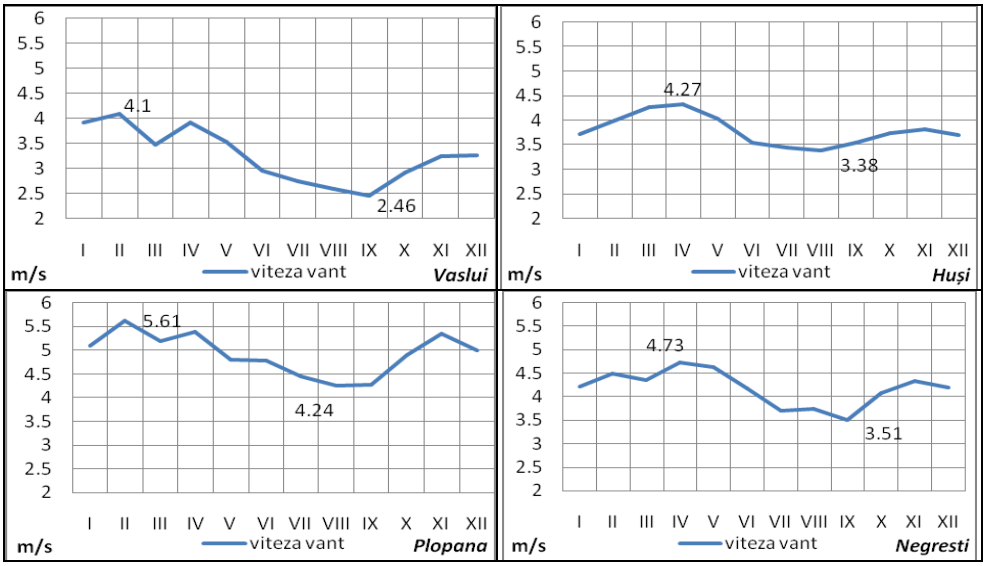

Fig.8. Monthly average wind speed for all stations (1965-1975)

In the area of study the maximum suitability was in the months February (Plopana and Vaslui) and April (Negreşti and Huşi). At Plopana and Vaslui was registered a second top in April. In June-September in all four stations was registered the lowest potential for developing wind energy, being frequent the atmospheric calm because of the typical baric conditions for the warm season.

Results

According to the study made it results that the energetic wind potential in Central Moldavian Plateau is the highest as the altitude is bigger, so at Plopana station, which is at the highest altitude of the four stations, it was registered the highest speeds of the wind, with a high variability, so a favorable energetic potential, well defined. In the areas of Negreşti and Huşi stations, the energetic wind potential is reduced, but enough for wind turbines up to 5 Kw. A wind turbine of 5 Kw, has the cut-in speed 3 m/s and can produce up to 2000 kw annually, which represents efficiency energetically speaking. For Vaslui, the wind energetic potential is very reduced, the average annual wind speed is very reduced, around 2.5m/s, situation in which the wind energy cannot be harnessed without wind turbines of domestic usage, of maximum 0.5 Kw, in on-grid systems, simultaneously with the electric network already existent, as well as in case of any types of usage of electric energy.

At a monthly level, at all stations it is observed, according to linear graphics, between June and September, the period with wind potential is reduced, thus at Vaslui station, due to this long unfavorable period, the energetic wind potential per year is low, and the investment in a wind system does not present trust, because the performance is very low.

In the areas studied within the Central Moldavian Plateau, according to the values of the wind speed, because of the altitude, but also because of local factors, the highest potential is registered at Plopana station, followed by Negresti, Husi, and at Vaslui station is the lowest energetic wind potential.

Following the analysis, at Central Moldavian Plateau can be said that it exists real possibilities of efficient usage of wind energy, present research, through a different methodology, confirming previous studies results.

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FREQUENCY OF THERMAL INVERSIONS BETWEEN SIRET AND PRUT RIVERS IN 2013

Pavel Ichim[1], Liviu Apostol[2], Lucian Sfîcă[3], Adriana-Lucia Kadhim-Abid[4], Vasilică Istrate[1]

Keywords: thermal inversions, frequency,

Abstract: Temperature inversions represent complex phenomena, specific for depression forms of relief which introduce changes in vertical zoning (Apăvăloae, Apostle, Pîrvulescu, 1986 by stable air stratification (Erhan, 1981), because of their morphological features, this is due to the interdependence of general movement and characteristics of the active surface, being the cause of their production (Apăvăloae, et. al., 1984, 1986, 1987). The generation of thermal inversions, their intensity and frequency is a consequence of altitude topography, morphology, fragmentation, orientation and degree of closure to external drives. (Apăvăloae, Apostle, Pîrvulescu, 1988). Thermal inversions represent complex phenomena, specific to depression landforms that introduce changes within the vertical zoning (Apăvăloae, Apostol, Pîrvulescu, 1986) by stable air stratification (Matveev, 1958, Erhan, 1981, Yinghui Liu, 2002) where vertical thermal gradient is negative (Matveev, 1958), due to their morphological features, also as a consequence of the interdependance of general circulation and characteristics of the active surface, the cause of their generation (Apăvăloae, et. al., 1984, 1986, 1987).

Introduction

Thermal inversions are associated with stable stratification conditions or „most stable" (Matveev, 1985), to the air in the low troposphere, persitance of atmospheric stability conditions. The increase in temperature with altitude, and various characteristics of air humidity, clouds and thermal inversions result in the formation of the inversion layer, aerosol transport and wind speed (Yinghui, Liu, 2002).

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In some conditions, thermal inversions can occur by radiative cooling, advection of warm air masses over the layer of clod air, as depression relief and and morphometry (Kahl, 1990, quoted by Liu, 2002).

Producing thermal inversions, intensity and frequency is a consequence of altitude terrain morphology, fragmentation, orientation and degree of closure to external drives (Apăvăloae, et. al., 1988).

Normally, the atmposhpere is characterized by a decrease in the elevation of the air temperature, in most cases the temperature tends to rise in altitude, which is characterized by a negative or null vertical thermal gradient (Apăvaloae, et. al., 1994).

When *the vertical thermal gradient is equal to 0 (zero)*, the air temperature is constant for a certain altitude difference isothermals are produced (Apostol, 1999), which represent „state of thermal instability of the atmosphere, neutral, have a a very low statistical probability of producing, the chances of determining them being reduced, these making the transition between the inversion layer and the air layer above the normal distribution of thermal gradients (Apostol, 1999).

Depending on the formation, thermal inversion phenomena are caused by a number of global factors felt throughout the year resulting from the roation of the Earth's radiative heat balamce seasonal and/or diurnal and seasonal variation of surface characteristicss underlaying assets. After the formation, thermal inversion phenomena include: radiation thermal inversions, nocturnal thermal inversions, winter thermal inversions and snow (spring) thermal inversions.

2. Data and methods

The studied area is represented mostly by the area between Prut and Siret valley containing a large part of the historical province of Moldova (fig. 1).

The interest area is placed about 3 ° latitude and about 2 ° longitude, which provides a longitudinal climatic setting quite diverse.

The landscape is characterized by heights ranging between 0 m (in lower plain of Siret river and Prut river at the confluence of the Danube) and 586 m- Dealul Mare-Harlau (Peak Tudora).

Morphometric speaking, on the studied surface the most representative altitudinal class is between 100-200 m altitude, with a share of about 42.2% (Fig. 2) it is specific in the south of the territory and over watercourses. Lowest weight belongs to the altitude class which has altitudes above 500 m with a approximate rate of 0.1%, these heights being specific for Dealu Mare Hârlău and for Culmea Doroșan from Colonele Tutovei.

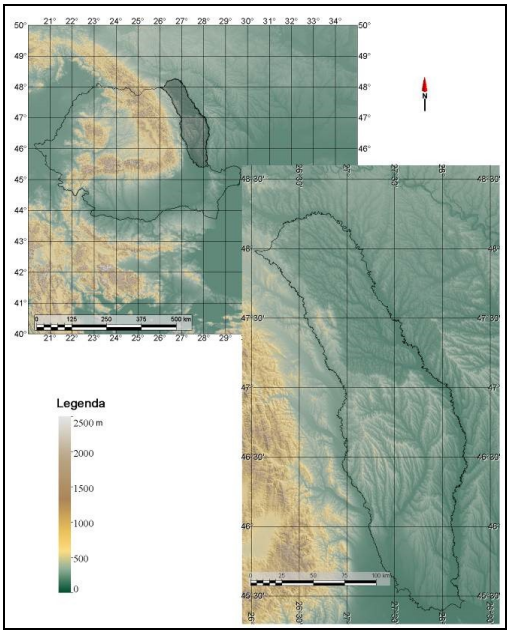

Fig. 1. Locating the study area in Romania

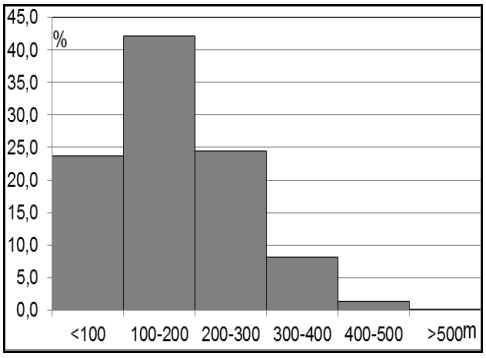

Fig. 2.The frequency distribution of elevation classes in the region between the rivers Siret and Prut

The experimental observation network includes 14 observation points including: two automatic weather stations (Cârja, and Mădârjac) and 12 data loggers (Larga Jijia, Dacia, Dancu, Ştefăneşti, Ciric, Răducăneni, Roşieşti, Roman, Tudora, Păun, Ivăneşti, Deleni), (tab. 3.).

First observations were conducted in Roman region, since December 2011 and the observations were aiming just a series of experiments regarding behaviour and recording of the data loggers, battery life autonomy, real time comparison between N.M.A. data and Roman meteorological station.

Observations were also realised at a 6 hour interval for Răducăneni, Larga Jijia and Roșieşti points, starting the summer of 2011 but the data loggers fucntioned without meteorological shelters until November 2012. Thermal values registered were extremely high, thus forcing the team to shelter all data loggers mentioned above. V

The present study assumed at first conceiving and designing mini weather shelters similar to those used on convetional meteorological platforms, shelters in which the data loggers were installed responsible for registering air temperature and humidity values at 1 hour interval.

Tab.1. Observation points that sum up the experimental observation grid

Nr. Crt.	**Station name**	**Type**	**ALT.**	**LAT.**	**LONG.**	**Functioning interval**
1	Cârja	s.m.a.	21	46º 09`	28º 06`	08.2012 -> present
2	Larga Jijia	senz.	42	47º 21`	27º 22`	08.2011 -> present
3	Dacia	senz.	44	47º 10`	27º 32`	12.2012 -> present
4	Dancu	senz.	60	47º 09`	27º 40`	11.2012 -> present
5	Ştefăneşti	senz.	60	47º 50`	27º 14`	11.2012 -> present
6	Ciric (Veneţia)	senz.	63	47º 09`	27º 37`	12.2012 -> present
7	Galaţi	S.M.	68	45º 28`	28º 02`	-
8	Iaşi	S.M.***	104	47º 10`	27º 37`	-
9	Răducăneni	senz*	136	46º 57`	27º 55`	06.2011 -> present
10	Roşieşti	senz.	142	46º 26`	27º 53`	06.2011 -> present
11	Botoşani	S.M.	161	47º 44`	26º 38`	-
12	Bacau	S.M.	182	46º 31`	26º 54`	-
13	Roman	senz.	205	46º 56`	26º 54`	12.2011 -> present
14	Mădârjac	s.m.a.**	252	47º 03`	27º 15`	10.2012 -> present
15	Tudora	senz.	256	47º 30`	26º 38`	10.2012 -> present
16	Păun	senz.	347	47º 05`	27º 39`	11.2012 -> present
17	Mănăstirea Ivăneşti	senz.	460	46º 37`	27º 24`	10.2012 -> present
18	Deleni	senz.	487	47º 29`	26º 50`	10.2012 -> present

*Temperature and humidity sensors
**Automated meterological stations
***N.M.A. meteorological stations that transmit in the sinoptic international flow.

The mini shelters have reduced dimensions compared to standard one (30x30x30 cm) and are realised entirely out of wood. After installation and

assembly, two layers of white paint were applied on the outside of the shelter and of black paint on the inside.

Fig. 3. Shelter materials (left) and shelter assembly (right)

Each shelter was installed at standar height observation (2 m) on grassy and open areas, avoiding as far as possible natural shading during the day (fig.4).

Fig. 4. Mini meteorological shelter (left); Mini-shelter at 2 m standard height at Tudora, Jud. Botoşani observation point (right)

Instrumentation used. The experimental observation network includes 14 points installed by the team, to which we addeed the 4 weather stations that transmit in international synoptic flow. As mentioned above, the team tried an uniform coverage focused specially on a homogeneous altitudinal distribution with respect to the official meteorological network.

The altitude plateau ranging between 100- 200 m has the largest share (42.2%) within the region. In this altitude range are three weather stations that are part of the official N.M.A. and transmit hourly data in international synoptic flow. In this altitudinal range, two experimental observation points (tab.2).

Răducăneni observation point (136 m) links profile between Păun and Valea Prutului observation points.

Tab. 2. Frequency classes of altitude and the number of observation points.

Altitudinal class (m)	Frequency (%)	Number of observation point
<100	23,7	7
100 – 200	42,2	5
200 – 300	24,5	3
300 – 400	8,2	1
400 – 500	1,3	2
>500	0,1	0

Observational point Roșieşti (142 m) is located in a tightly closed micro depression, very well enclosed that is drained by Idrici river, left affluent of Bârlad river. The enclosed depression landform gives it a unique character. This observation point connects Ivănești and Cârja observation points.

Higher altitude levels present lower heights, but as distribution pattern regarding the thermal inversion pheomena they are considered as crucial observation points. Within the region there are three observation points at altitudes greater than 300 m.

Păun observation point operates at 347 m altitude which is considered as a junction point linking a series of profiles that we want to analyze the phenomenon of thermal inversion. It represents the bridge connecting the other observation points installed in Iassy alongside meteorological station of Iassy and Răducăneni observation point.

Ivănești observation point is located in Similea hills and function at 460 m altitude and it is also the link to the profile crossing from west to east the central-southern part region of the alignment Bacău – Ivănești – Roșieşti - Cârja.

Highest altitude observatins within the region is 487 m at Deleni observation point located in Dealul Mare- Hârlău. This point connects, in terms of

observations, the northen central part of the region. Observation points that we consider to be related are: in the north part Botoşani meteorological station, in the west Tudora observation point, north-east Ştefănești observation point and in the south-east part Larga Jijia observation point, this relationship also having the highest relative latitude of aproximately 445 m.

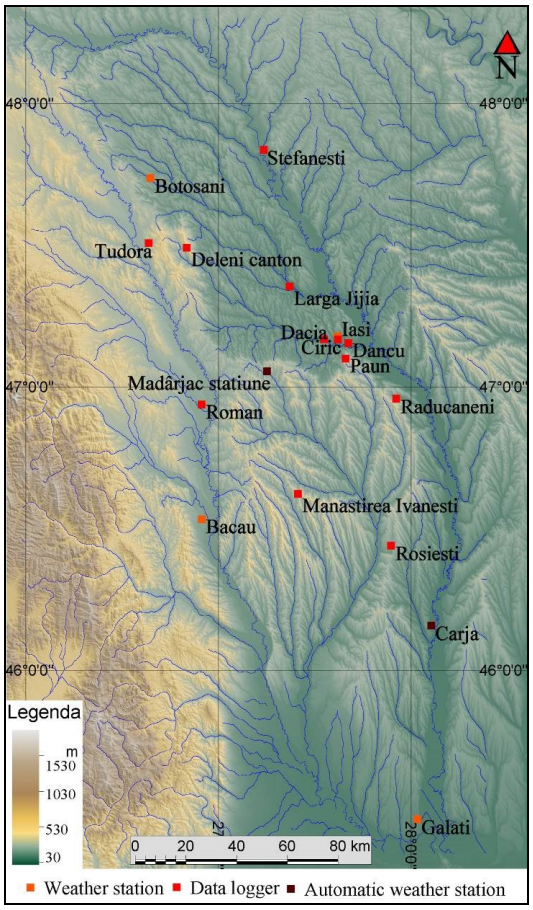

Fig. 5. Experimental observation network between Siret and Prut rivers

Cotnari observation point functions at 265 m altitude near Cotnari village. This point connects other observation points towards Siret river and Moldavia Plain, comparable with Deleni observation point.

For this study hourly data obtained in the experimental observation network were used, together with a series of common observations from 2013. Th frequency of the thermal inversion phenomena were calculated for each profile.

2. Results and discussions

2.1. Annual frequency of the thermal inversion phenomena

In romanian literature there are no works regarding thermal inversion phenomenon at hourly occurence over a one year period of time. In most romanian literature in which reference is made on thermal inversion phenomena they are associated in most cases with particular periods of abrupt cooling, specific to the cold semester. On an annual basis there are a series of references regarding the thermal inversion phenomenon especially in the mountain area.

High latitudinal extension of the area offers a series of thermic differences which are induced first of all in the caloric radiative balance, air mass dynamics, morphological and morphometric parameters.

Using monthly mean data one can not determine the frequency of thermal inversion phenomena, especially those relative to radiation that produce in the first part of the day and they occur for a short period of time being easy dissipated after sunrise.

The entire region is distinguished by an average frequency of thermal inversion phenomenon of arpoximately 24.7% (Fig. 6).

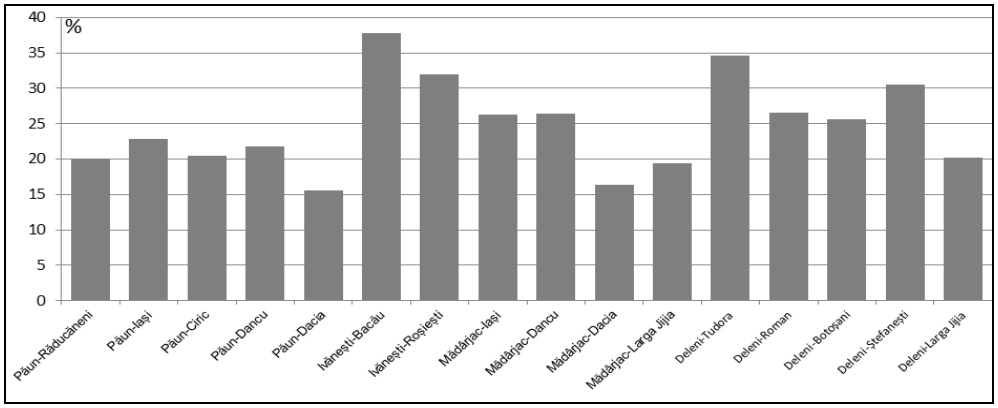

Fig. 6. Annual frequency of the thermal inversion phenomenon during 2013

For 2013 high frequencies of the inversion phenomenon are distinguished within the Siret corridor. In the year 2013, the hourly monitored inversion phenomenon present a frequency share of aproximately 38% on Ivănești-Bacău

profle but little further north on Deleni-Roman profile, where phenomenon frequency was lower, reaching a frequency of 26%. Lower inversion phenomenon frequency could be explained by the position of the observation point, that being located on the outskirts of the city. In these circumstances the heat generated by the anthropogenic surfaces is felt and it is influencing to some extent the thermic regime of this observation point. The northern part of Siret river can be distinguished through a frequency of the thermal inversion phenomenon of aproximately 34% on Deleni-Tudora profile.

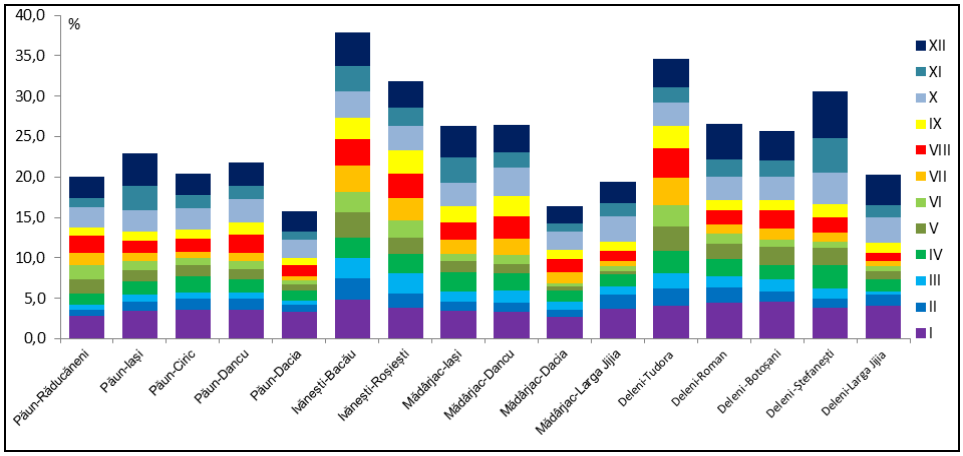

Fig. 7. Monthly frequence of thermal inversion phenomenon in 2013

Annual thermal inversions rate regime is characterised by large values mainly during the cold semester, with highest frequencies registered in January when profiles of Siret river observation points are highlighted. High frequency of situations regarding atmpospheric stability conditions generated by the anticyclones baric formations determine an increase of thermal inversion phenomenon frequency specially in „closed" lowlands areas.

Within the profiles there is high frequency highlighted pertaining to the thermal inversion phenomenon during winter, especially during January and December (fig. 7).

Profiles Ivănești – Bacău, Deleni – Tudora, Ivănești – Roșiești and Deleni Ștefănești are distinguished by the highest values of thermal inversion phenomena with largest monthly values throughout the year (fig. 7).

In general, the spring season is poorly represented in the incidence of the thermal inversion phenomena except the analyzed profiles in correspondance with area of Siret river. Atmospheric dynamics is more intense during spring months

which induces turbulent mixing of air masses existing in low troposphere, greatly reducing the frequency of thermal inversion phenomena.

Daily frequence of thermal inversion was calculated based on the average daily temperature values and compared on profiles for pairs of two stations. This type of frequency highlights very well the circumstances in which the phenomenon of thermal inversion that occurred in high intensity actively influenced the thermal regime of the air temperature in certain areas.

Through morphometric and morphological particularities, corroborated with the intense foehn phenomena specific to Dealul Mare Hârlău region, the number of situations with thermal inversion with strong intensity highlights the profiles Cotnari – Tudora, Cotnari – Roman, Deleni tudora and Ivănești – Roșiești. Within these sections we can distinguish high frequency in the daily average values, both during the cold semester as well as the hot one (fig. 8).

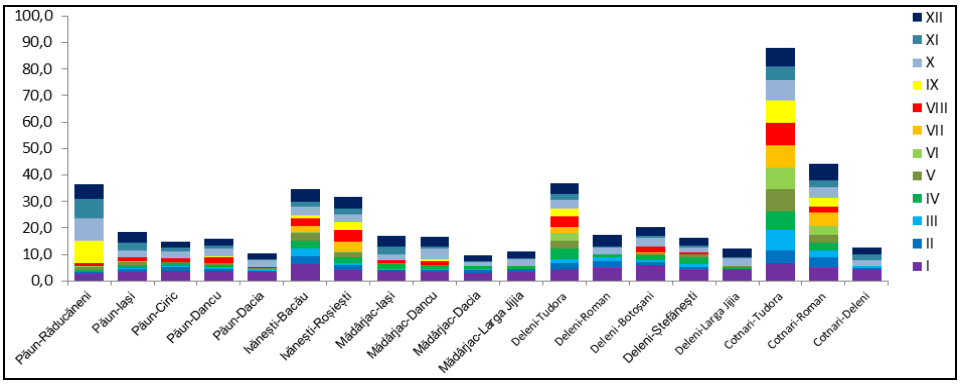

Fig. 8. Daily frequence of the thermal inversion phenomenon

The profile Păun – Răducăneni is characterized by extremely high frequencies of the year 2013 during the autumn season. The high incidence that thermal inversion phenomena generated low values for the daily average temperature of the autumn season.

Low frequencies outlined in the urban areas (Dacia observation point) and regions with large water surfaces. Although the phenomenon of thermal inversion occurs throughout the year in these profiles impact on the average daily temperature is not felt in the thermal regime.

Major differences in the evolution of thermal inversion phenomena frequency between the aisle areas, micro depression landforms and areas with a lower degree of fragmentation it can be deduced that to some extent the intensity degree pertaining to thermal inversion phenomenon. Thus, the thermal inversion episode is

intense (even if radiation is a thermal inversion), the mean temperature of that day will be lower than those recorded at higher altitudes.

2.2. Hourly frequency of the thermal inversion pheomenon

2.2.1. Thermal inversion phenomenon frequency in the interval 01:00 – 06:00 a.m. During the year, the phenomenon of thermal inversion occurs cyclically reaching maximum frequency required in the thermal regime especially during the cold semester. In the daily regime, the thermal inversion frequency is intensified during night time. Thus, between the hours 01:00 to 06:00, the frequency of the thermal inversion phenomena recorded values exceeding the average annual frequencies. In these conditions we can equally distinguish all relationship analyzed, most common being those calculated on the corresponding profiles towards Siret river, which present specific frequencies of aproximately 50-55 % during 2013 between the hours 01:00 - 06:00.

The radiative inversions that manifest on the background of radiative cooling specific to the night regime induce a grow in frequency after midnight and continues to grow in frequency during the night until the early hours. Maximum frequency of manifestation for the thermal inversion occurs predominantly around 05:00. The time for maximum thermal inversion occurence depends on the time when the sun rises, is limited by atmospheric dynamics and local peculiarities of the relief, the frequency gradually ranging from one month to another.

In the thermal inversion frequency specific for 01:00 – 06:00 interval it stands out through almost equal frequencies for each month of the thermal inversion occurence throughout the year. Large frequencies can be observed (fig. 9 - 14) pertaining to thermal inversion phenomenon both for the cold season as well as the warm semester. High frequencies of thermal inversion phenomenon occur due to radiative cooling of the air in the immediate vicinity of the ground and especially on slopes where it becomes denser and is driven by gravity to the bottom of the valley. During situations characterized by atmospheric calm, the air is denser hence implicitly colder, it gets stratified favoring thermal inversion phenomenon occurence.

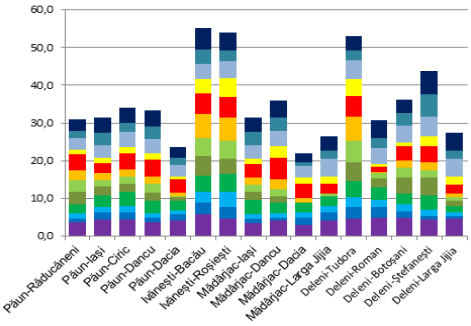

Fig. 9. Thermal inversion phenomena frequency at 01:00 a.m.

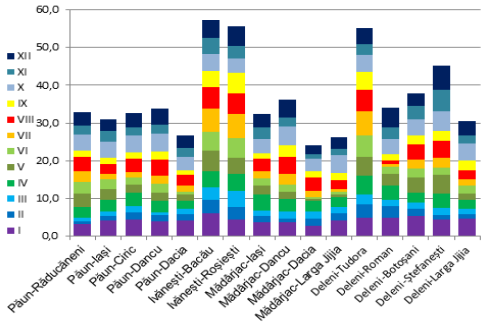

Fig. 10. Thermal inversion phenomena frequency at 02:00 a.m.

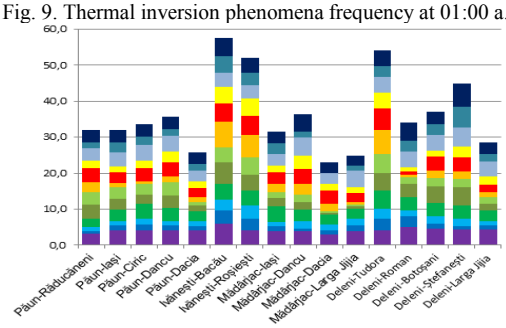

Fig. 11. Thermal inversion phenomena frequency at 03:00 a.m.

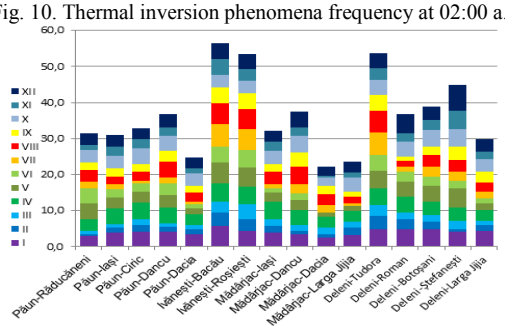

Fig. 12. Thermal inversion phenomena frequency at 04:00 a.m.

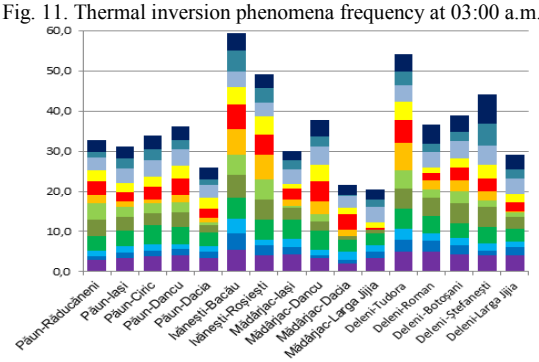

Fig. 13. Thermal inversion phenomena frequency at 05:00 a.m.

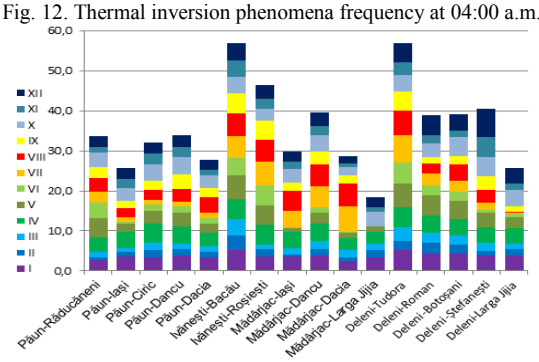

Fig. 14. Thermal inversion phenomena frequency at 06:00 a.m.

Except Siret valley areas, in the hourly development of thermal inversion we can distinguish Roșiești observation point. This closed micro-drepression character offers ideal conditions for stabilization and sedimentation of cold air which remains trapped in the bottom of the valley.

Lowest thermal inversion phenomenon frequencies are characteristics to open areas with low fragmented relief. An example can be presented in the case of Larga Jijia observation point compared with Mădârjac meteorological station. The

position of the Larja Jijia observation point located inside the Larja Jijia farm induces a moderate topoclimate, specific to water accumulation. This feature determines low frequencies of thermal inversion phenomenon on this profile.

2.2.2. Thermal inversion phenomenon frequency in the interval 07:00 – 12:00 a.m. With sunrise, the thermal inversion phenomenon frequency gradually decreases. Major difference can be observed from one hour to another. Largest differences are observed in the warm semester where due to the increase of the caloric radiative flow, thermal inversions start easily tobe dissipated by the ascending caloric flow.

In this frequency range the theral inversions falls to the point where stability layer is removed. This development is felt especially when specific radiative inversions related to the summer months, leading most cases to the destruction of the horizontal inversions towards the afternoon.

We also observe it in the situation of Siret river which stands out as an area where the hourly rate decreases slowly, dropping below 30% just after 11:00. Radiative thermal inversions in the Siret river area that form during summer months especially during August, during which high levels of thermal inversion frequency are preserved.

Winter months, especially in December and January are characterized by high frequencies generated by enhanced stability situations, specific to anticyclones baric formations that impose within the thermal regime through negative air temperature values.

Thermal inversion phenomena generated by dynamic factors particularly those of frontal origin are imposed in the hourly frequencies. Thus, at 11:00 on Ivănești – Roșiești profile a total frequence of aproximately 6% is observed and then again at 12:00 it can be distinguished through a frequency of about 8.8%. One can notice the increase in frequence of thermal inversion formation. The depression landform and the high degree of storage pertaining to this landform form ideal conditions related to preserving the cold air masses within the landform, very difficult to dislodge the warm front passage.

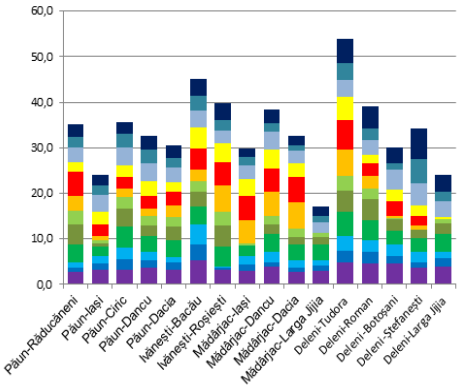

Fig. 15. Thermal inversion phenomena frequency at 07:00 a.m.

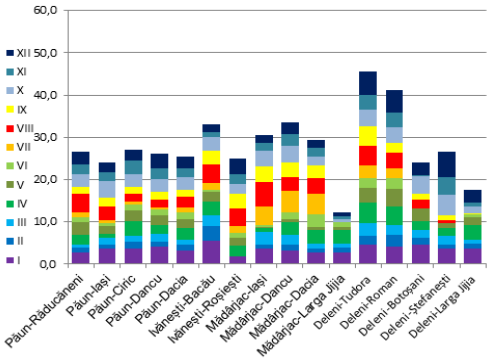

Fig. 16. Thermal inversion phenomena frequency at 08:00 a.m.

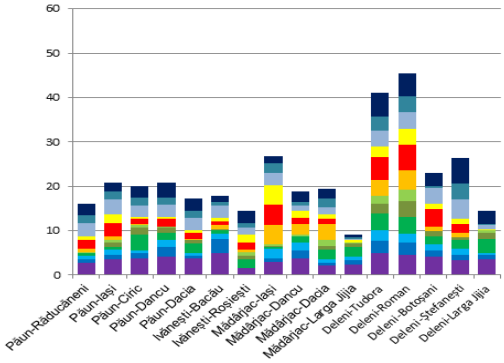

Fig. 17. Thermal inversion phenomena frequency at 09:00 a.m.

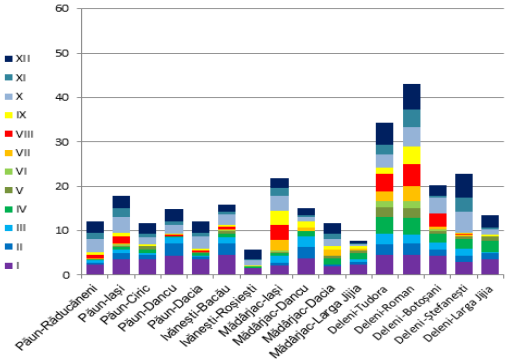

Fig. 18. Thermal inversion phenomena frequency at 10:00 a.m.

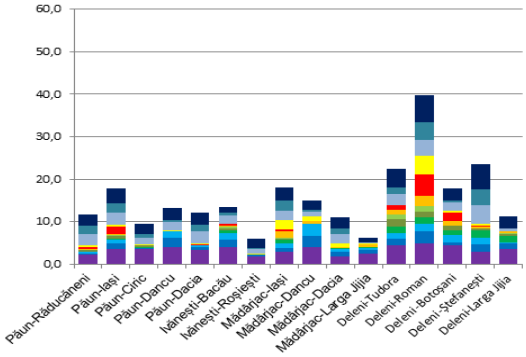

Fig. 19. Thermal inversion phenomena frequency at 11:00 a.m.

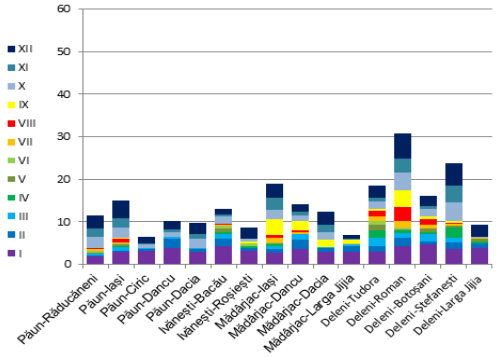

Fig. 20. Thermal inversion phenomena frequency at 12:00 a.m.

2.2.3. Thermal inversion phenomenon frequency in the interval 13:00 – 18:00 p.m. Between 01:00 to 06:00 the thermal inversion phenomenon decrease in frequency for all calculated profiles. Highest frequencies remain those specific to depression and aisle landforms. Throughout the year during this time interval are dominant convective processes that induce normal stratification of vertical air temperature values, generated by the high radiative heat flow.

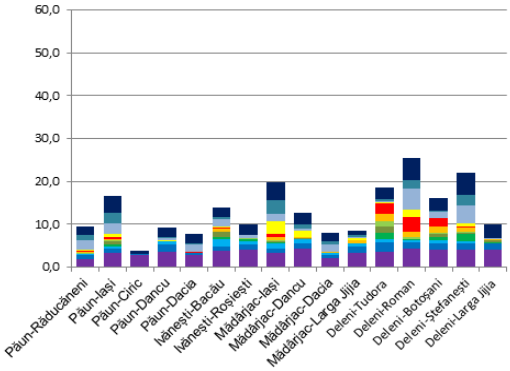

Fig. 21. Thermal inversion phenomena frequency at 13:00 p.m.

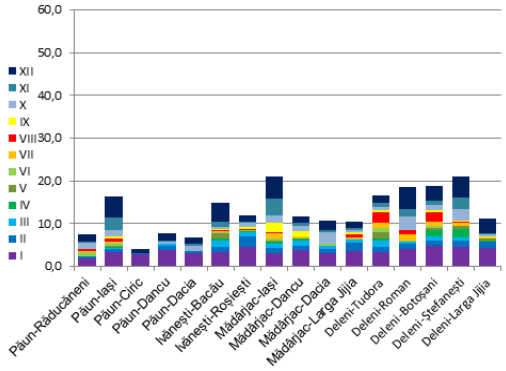

Fig 22. Thermal inversion phenomena frequency at 14:00 p.m.

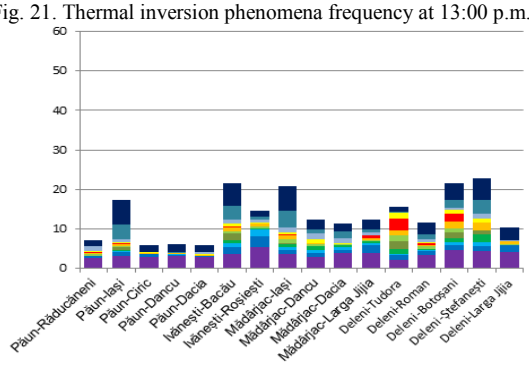

Fig. 23. Thermal inversion phenomena frequency at 15:00 p.m.

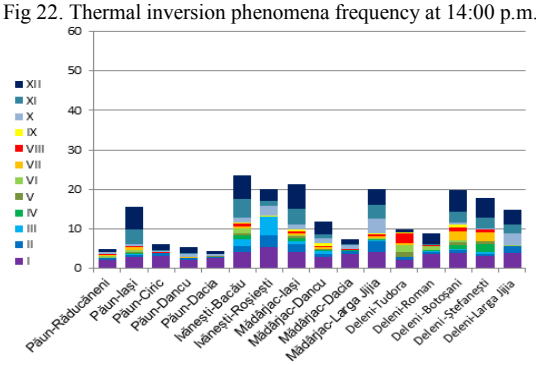

Fig. 24. Thermal inversion phenomena frequency at 16:00 p.m.

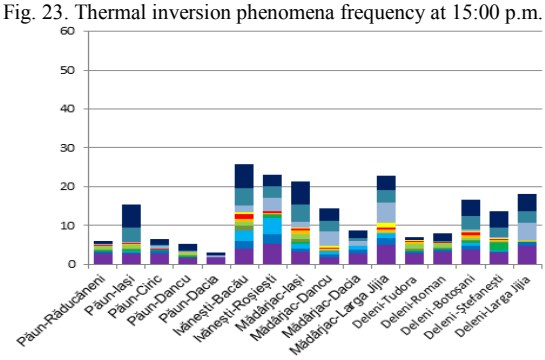

Fig. 25. Thermal inversion phenomena frequency at 17:00 p.m.

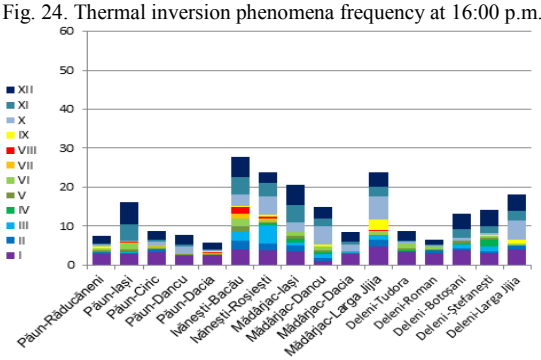

Fig. 26. Thermal inversion phenomena frequency at 18:00 p.m.

Largest frequencies of the thermal inversion phenomenon in this time span represent direct consequences of marked atmospheric stability situations and cloud formation during the cold semester.

2.2.4. Thermal inversion phenomenon frequency in the interval 19:00 p.m. – 00:00 a.m. Along with the decrease in the incidence angle of solar radiation, the intensity of the flux decreases and the caloric radiative heat flow to the end of the day. In atmospheric stabilty conditions the air descends, gradually cooling as it gets

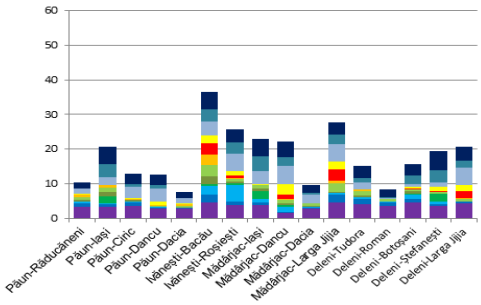

Fig. 27. Thermal inversion phenomena frequency at 19:00 p.m.

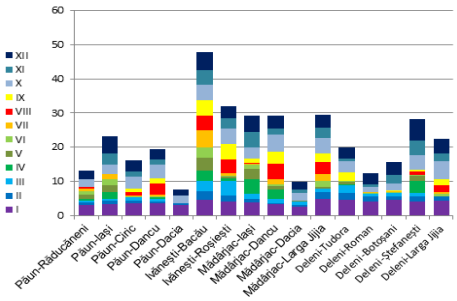

Fig. 28. Thermal inversion phenomena frequency at 20:00 p.m.

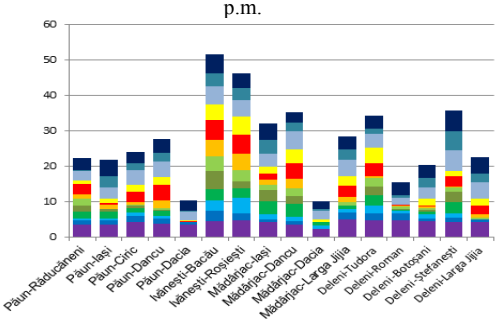

Fig 29. Thermal inversion phenomena frequency at 21:00 p.m.

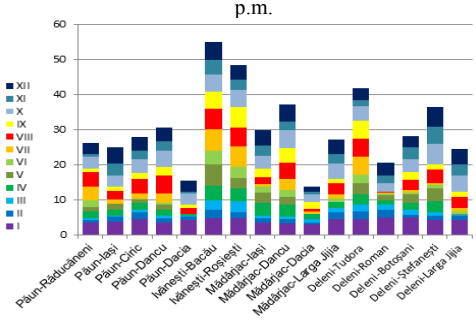

Fig 30. Thermal inversion phenomena frequency at 22:00 p.m.

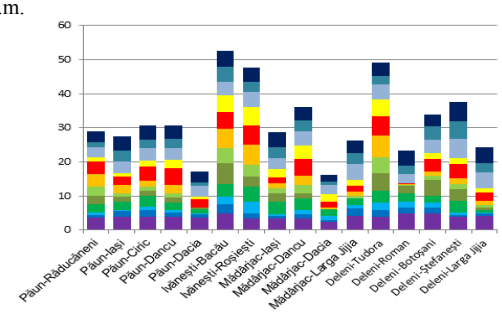

Fig 31. Thermal inversion phenomena frequency at 23:00 p.m.

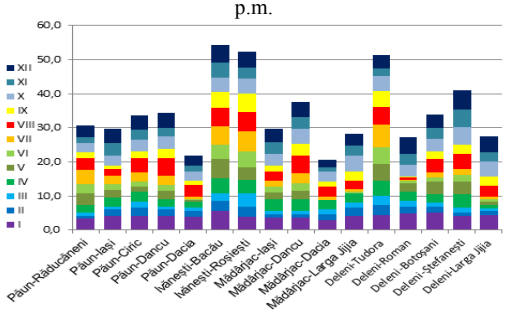

Fig 32. Thermal inversion phenomena frequency at 00:00 a.m.

lower to the ground. In most cases, compression inversions (sedimentation) increase in frequency towards the second part of the day.

The interval 19:00 – 00:00 is characterized by progressive increase in frequency regarding the thermal inversion phenomenon on all the analyzed profiles. This increase is produced synchronously at all points of observation, approaching specific frequency values specific to 01:00 a.m.

Conclusions

Mild thermal inversions occured throughout the year with a higher frequency in the cold months of the semester. Still, if they occur during transition seasons they can generate cold waves and frost periods phenomena associated with the occurrence of sudden cooling (rime, glaze, etc).

At regional level it can be distinguished a number of areas where the frequency, duration and intensity of thermal inversion phenomenon manifest itself in different ways. Siret river is highlighted by large frequencies of thermal inversion phenomena that occur throughout the year, reaching the highest frequenies in both montlhy and hourly regime.

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