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THE EVOLUTION OF ANTHROPOGENIC IMPACT UPON ENVIRONMENT RESULTING IN MODIFICATIONS OF THE SOIL CHARACTERISTICS IN BACAU URBAN AREA

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Résumé. La présentation porte sur les analyses de sol par l`analyse de 56 preuves de différentes endroits, répandues (dissipées) sur des différentes directions et distances des sources majeures de pollution, avec des échantillons prises à une profondeur de 100cm en ordre de la réalisation des analyses des standards pédologiques. Autour de chaque preuve les mesurages moyennes ont été faites sur 100 m^2 pour déterminer les éléments polluants (fluorine et métaux durs). Les plus importantes modifications concernant les caractéristiques du sol apparaissent sur les plates-formes industrielles, après l`excavation des matériaux, mouvement des materiaux, nivellement avec des matériaux de type débris, dans le cas des unités mécaniques, des haldes de terril résiduel en polluant le sol avec des métaux durs. Dans le sud, l`usage des compostes qui porte sur le traitement biologique des boues conduit à la même pollution des sols. Dans l`ouest, les terrasses de 50-60m, à destination militaire, les sols sont marqués du phénomène de subsidence sous la pression des véhicules d`où il résulte des modifications des propriétés physiques,(structurelles et la perte de la perméabilité). Les components acides de l`atmosphère ont doublé l`acide des sols(pH5.5-5.8) utilisé dans des buts agricoles dans les dernières 25 années.

The city of Bacău, comprising 210.000 people, lies in eastern Romania, in a hilly region, on flat terrain, along the Siret river corridor (with 80 m^3/s debit), at the junction with the Bistrița river (60 m^3/s), between the altitudes of 150 and 210 m. The relief is almost entirely flat, being occupied by the Bistrița and Siret rivers and their terraces, the only steep sectors being represented by the terraces' fronts. The largest part of Bacău's urban area lies between 165 and 175 m. The administrative area measures 32 km^2, with 16.5 km^2 of urban fabric and 15.5 km^2 of green belt. The urban fabric includes one quarter of blocks wards, the rest being

occupied by one or two levelled buildings, yards, parks, gardens, the Bistrița river and leisure lakes, communication infrastructure, and industrial units situated at the periphery and constituting sources of pollution, especially, in the eastern and the southern part of the city.

The hydro-energetic lake situated on Bistrița, Bacău II and the adjacent leisure lake have large surfaces reported to the urban area (urban fabric and green belt) and play an important role in the underground water level rising in the meadow areas and, also, in the air masses circulation. Between January and June, the aquatic surfaces temperature is lower than the air temperature, the pressure is higher and the local descending air currents reduce the precipitation quantities; the horizontal dimension is controlled by divergent currents which bring fresh, non-polluted air in the urban area. Between July and December, the temperature of the above mentioned aquatic surfaces and the Bistrița River are higher than those of the adjacent air masses resulting in ascendancy (also due to humidity rise), convection rise and a local air circulation oriented toward the lakes area. There are also slight diurnal circulations, lake breezes going from the lakes to the city at night and during mornings and reversing in day time.

The city of Bacău, situated at the 46^{o} 40' latitude, belongs to the southern half of the temperate transitional climate. The average annual temperature is 9.2^{o}C, with the lowest monthly average in January ($-2,6^{o}$ C) and the highest in July ($20,5^{o}$ C). The soil surface annual average is $10,6^{o}$ C, with the lowest monthly average in January ($-3,0^{o}$ C) and the highest in July ($24,3^{o}$ C). The relative humidity has an annual average of 81%, with the lowest monthly average in July (76%) and the highest in January 88%. The total cloudiness has an annual average of 6.1, with the lowest monthly average in August (4.5) and the highest in December (7.3).

The sun shines with an annual average of 1910 hours, with the lowest monthly average in December (60,6 hours) and the highest in July (270.5 hours). The annual average precipitation is 564.9 mm, increasing from January (21.7 mm average) to July (83.7 mm average). Even if the monthly average quantities increase 6 times between January and July the average number of days with precipitation does not show great disparities. The monthly averages rise from September, 7.7 days, to January, 10.3 days with a secondary minimum in February, 9.6 days and the main maximum in June, 13.1 days. The average number of days with liquid precipitation is 109.2, the monthly average being high even in the winter time (4.4-6.4 days). The annual average number of days with snow cover is 64.9, with the earliest appearance in November and the latest in May and the peak in January (average of 19.4 days). The atmospheric calmness high frequency (40.6%) induces the aerosols deposition in the urban area and maintains the gas pollutants in their sources vicinity. The predominant winds blow along the Siret corridor from north to south. The most frequent is the northern direction (16.5%) being characteristic for the sector stretching east from the Eastern Carpathians; the

second is the southern direction (15.7%) which brings atmospheric pollutants from the industrial platforms lying in the southern urban area. The third place is represented by the north-western direction blowing along the Bistrița river corridor.

Soil evolution in the urban area developed in close connection with the natural pedogenetic factors combined with the influence of anthropogenic factors which became more intense in the last two centuries. The anthropogenic factor accentuated along with the urban and industrial development. From its settling in the 14th century until the 18th century, the feudal town developed slowly maintaining the commercial and crafts functions.

The capitalist development in the 19th century is linked with the town location, on an important communication axes (going from Poland to Turkey), and with the wood and fur processing industry. The rapid development which took place in the 20th century relied on celluloses and paper industry, wood processing, machines, constructions, chemical composts production, food industry, etc. and resulted in population increase, from 100.000 to 200.000 in four decades. The modern city, the hydro-energetic constructions and the industrial plants were built in the last 45 years. During this period the present urban profile was shaped through the edification of the industrial platforms, too close to the urban area or at small and medium distances and with a great density of blocks covering half of the city area. Almost all of the blocks (of flats) have four levels and the individual households have yards and gardens, the ones situated at the periphery being very large.

The construction activities for the industrial platforms, the wards area, the hydro-energetic systems and the communication network resulted in great soil cover modifications. Large excavation sites, removal of soil cover, parental materials and exogenous materials mixed with the natural soils are the most important modification factors. The last four decades also brought atmospheric pollutants, dusts and acid rain which acted after deposition and gases which acted via contact and on small surfaces, and, less via surfaces and underground water circulation.

The polluted surface waters resulting from deposits washing infiltrated in the soils during rain falls or from the polluted rivers and lakes. It is worth mentioning that, until 1990, the Bistrița river (60 m^3/s) did not match any classification category.

The environmental preoccupations, characteristic for Western Europe since 1975, did not materialize in the case of Bacău through efficient solution because, until 1989, the major interest was on production volume. The environmental measures, rather expensive, represented only a declarative issue, especially because no funds were allocated in this respect. The main action consisted in the

construction of high industrial evacuation pipes in order to direct the pollutant fumes at longer distances.

The lower part of Bacău lies on the Bistrița river meadow on "lithic and calcaric luvisols", the medium part lies on the 35-40 m terrace on "haplic chernozems" and the highest part lies on the 50-60 m terrace, on "calcic luvisols". The main polluting sources of the water and, more important, of the air are: the "Sofert" chemical compost plant and the power-plant located at 2 km south of the urban area; the "Letea" celluloses and paper unit from east and the motorized vehicle traffic.

The principal air pollutants are: ammonia, nitrogenous oxides and sulphur dioxide. The background pollution is moderate to low and comes from two main directions: the first from the Ruhr basin, Czech Republic, northern Hungary and the second from the Moscow's power-plant region which is less harmful.

The air pollutants effects on soils achieved through direct contact and gases exchange is less important compared to the effect of gravitational aerosols deposition and acid rains. The acid rain phenomenon is rather characteristic to the northern temperate zone, heavy industrialized, urbanized and with an intense motorized vehicle traffic.

The city of Bacău is located in the acid rain area which stretches in Europe from the United Kingdom, through southern Norway and Sweden, the southern bank of Finic Gulf and, to the south from northern France, through the Rhin's valley, Central Italy and central Balkan Peninsula, the western and northern banks of the Black Sea and the Azov Sea. Following the alignment of the Finic Gulf – Azov Sea, which represents the short axes of this rhombus like shape to include the acid rains area, the area tends to narrow towards the Perm region and the Central Ural, follows the coal extraction area of Karaganda and points its peak to Kuznetsk. The determinations made on mineral iron deposits, in Europe, show the highest values for Central and Eastern Europe. (De Vries, 2000)

The long term influence of the atmospheric pollutants on soils, especially of nitrogen oxides and sulphur dioxides brought by polluted rainfalls, resulted in soils acidification where the agricultural soils with moderate acid reaction have doubled (pH 5.5-5.8) and the arable soils, in the green belt area, the moderated acid soils increased 2.5 times in only 25 years.

The main meteorological parameters implied in the air pollution and cleaning refer to the northern winds dominance, which are polluted winds, followed by the southern fresh winds, the atmospheric calmness (40%), the high frequency of thermal inversions and fog, during winter time.

The economic development in Bacău and the periphery resulted in certain negative impacts due to anthropogenic activities, which ended in soil pollution as a direct consequence of industrial, agricultural and other urban enterprises or motorized vehicles emissions. The pollution also developed through defective

management as far as the organic sewage waste and the solid waste is concerned. The atmosphere is also polluted by industrial activities, motorized vehicles emissions, households heating systems and, indirectly, through the polluted small depth underground water or irrigation polluted water **(fig.1).**

Industrial pollution is the main environmental pollution source and it is generated by the activities at: SOFERT S.A, *Letea* Paper Production Unit, AEROSTAR Bacău, CET Bacău, the Protan Facility, the metallurgical units, the machines and tools units and the construction facilities, etc. These facilities put out, selectively, waste waters, phosphor-gypsum dusts, iron sulphide ashes, ammonia emissions, sulphur and nitrogenous oxides, carbon dioxide, heavy metals, hydrogen sulphide, organic and organic residuals, salts, acids, cinders, even pathogenic agents.

The pollution resulted from agricultural activities refers to the ammonia emissions from the animal farms, the usage of biological treated muds as fertilizers and the insufficient treated waste waters or the use of unclean waters from accumulations for irrigation purposes.

The pollution resulting from households waste and residual waters becomes more and more harmful for the environment. The households' residual wastes are neither properly stocked nor controlled and do not suffer mixture processes or incineration in order to be reduced. The residual waters are poured directly or very less filtered in the hydro-graphic network, defying the environmental issues and contain excessive organic loads, lots of salt compounds, heavy metals, detergents, pathogenic agents, etc. This high content of toxic compounds in these waters makes them not suitable for fertilization in agriculture.

The soil analyses performed in this urban area can describe the pollution processes that affected the soil cover.

The influence of solid suspension emissions on soils materialized in a constant soil acidification process. The vast research conducted in the Siret corridor, between Săuceşti (up-stream) and Răcăciuni (down-stream), for the nineties as compared to the eighties, shows the appearance of strong acid perimeters, the increase of moderated acid surfaces, with 10.7% and the decrease of other classification categories.

That is why the low acid terrains decreased with 6.7%, the neutral ones with 1.7%, the low alkaline with 0.9% and the moderated alkaline with 1.6% reported to the total agricultural land in this area. In numbers, the moderated acid surfaces, which require amendments, have tripled in the analyzed time span, from 1350 ha to 4990 ha. In correlation with this overall acidification the soils characterized by less than 75% bases saturation degree have decreased four times.

The acid surfaces extension has a great impact on plants nutrition with nitrogenous, determining nutritional disequilibria related to the macro and micro

elements and provoking soil capacity of retaining water and air. The soil reaction lowering resulted also in increased phosphorus and potassium retainment because of the pollution impact on alkaline meadow soils, where, pH lowering increased phosphorus accessibility for plants and also because of the agrarian policy to increase production which meant intense chemical fertilization. In the nineties, compared to the eighties, the soil which had a great mobile phosphorus deficits decreased with 15.8%, those with small deficits with 9.9% while the satisfactorily supplied soils (with mobile P) increased with 9.5%, the well supplied with 10.4% and the best supplied with 5.8%.

The lack of pointed studies for these urban area soils situation, in order to measure the input and output of N, P, K does not allow an accurate up-to-date appreciation of agro-chemical qualities.

Nitrogenous accumulations in soils and plants. The N emissions are made through ammonia from SOFERT Bacău and from the animal farms waste disposals while the nitrogen oxides are delivered by SOFERT and CET Bacău. The high concentrations in soils appear just insularly and around the emission sources. The most important are the nitrogenous oxides which give acid rains or infiltrate into the underground waters and, from here, reach people and animals. At the moment, the Bistrița meadow underground waters exceed the admitted limits for the ammonia and nitrous oxides but there is a constant decrease due to the economic activities decline in the regions situated up-stream.

Fluorine accumulations and soil quality. The fluorine accumulations come from the compost production at SOFERT Bacău and are represented by gases and dust which are disseminated around this industrial facility. Inside soils, fluorine can also appear through the use of phosphatic composts.

The performed determinations indicate the existence of higher quantities in the northern and the southern part of SOFERT unit, on the propagation way given by air circulation, and reveals values from 50 to 122.5 ppm which means that the pollution is insignificant. Even if the production is diminished, often ceased, the phosphor-gypsum residual pile lying in this area should be cleared for agriculture and also because it constitutes a pollution source for the atmosphere. (phosphor-gypsum dusts)

Heavy metal accumulations in soils are important for their presence in the soils at exceeding quantities and also because the respective areas suffer acidification which, hence, sustains the accessibility for these elements. The heavy metals studied here were: copper, zinc, lead, cobalt, nickel, manganese, chromium and cadmium.

The *copper* has normal values (under 20 ppm) for only 7 sampling spots. The majority of sampling spots present an overload but not exceeding the admitted limits which are between 25 and 45 mm. The highest concentrations of copper

appear in the vineyards and vegetable gardens sectors and have values of 50-60 ppm. This must be the effect of phyto-sanitarian substances which contain copper.

The *zinc* has normal values (under 100 ppm) in the majority of sampling spots; only 4 spots are to be considered polluted as they have an overload of zinc which exceeds the admitted limits. If we consider the general acidification of soils which has been taking place lately then we can predict that these elements will only become more mobile.

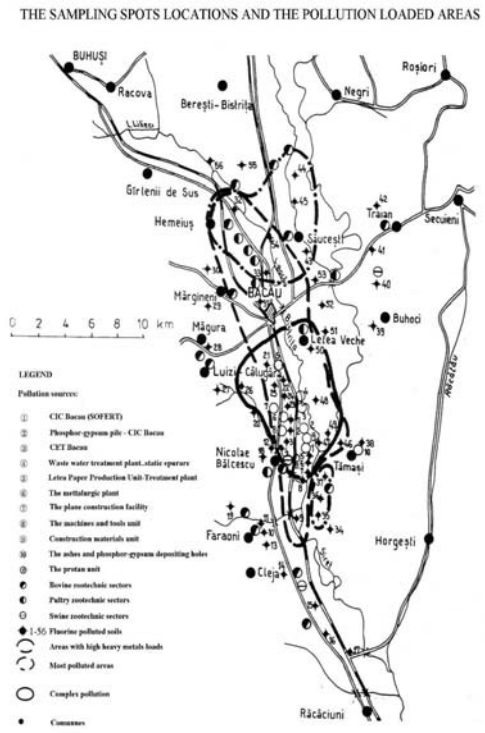

Figure 1.

The *lead* has normal values (under 20 ppm) in only 4 spots; the other samples indicated polluted soils with load under the maximum admitted limit (100 ppm). These are mostly a result of spark engines functioning. The increase of auto vehicles after 1990 exposed the urban area to a heavy emission propagation which resulted in lead accumulation in soils and plants and, hereafter in animals.

The *cobalt* has normal values of under 15 ppm. The samples show normal values in 24 spots and values under the maximum admitted limits in 32 spots. The spots with 20-25 ppm are relatively scattered while the spots of over 30 ppm are grouped in Siretu-Ruşi Ciutea area and to the west of Chetriş and Gioseni villages.

The *nickel* has normal values of 20 ppm and the maximum admitted limit is 50 ppm. In the studied area all the sampling spots exceed the normal values, and, in 10 of them the values are higher than the maximum admitted limit. The most polluted areas are Siretu-Ruşi Ciutea-Letea Veche, the areas situated west of Chetriş and Gioseni villages and those situated north and north-west of Bacău municipality.

The *manganese* has normal values of 900 ppm and the maximum admitted limit is 1500 ppm. The total sampling spots is 43 and they have a normal load of manganese, the rest, of 13 spots, are under the maximum admitted limit. These spots of low pollution appear in the Siretu-Ruşi Ciutea area, west of the Chetriş and Gioseni villages and south-east of Gh. Doja.

The *chromium* has normal values of 30 ppm and the maximum admitted limit at 100 ppm. The samples present loads under the maximum admitted limits of 70 to 90 ppm. Two spots, situated close to the Letea Facility and the Bacău's waste water treatment plant, exceed the maximum admitted values.

The *cadmium* has normal values of 1 ppm and the maximum admitted limit at 3 ppm. In 31 sampling spots the values are normal and in other 25 the values are between 1.5 and 3 ppm resulting in soils with low cadmium load, under the maximum admitted limits. The areas are: Siretu-Ruşi Ciutea-Letea Veche and west of Gioseni-Chetriş.

To synthesize the aspects of heavy metals load for soils the Siret corridor from Săuceşti (10 km north from Bacău) to Răcăciuni (25 km south of Bacău) presents areas of exceeding values as far as heavy metals are concerned.

In three of these areas, Siretu-Ruşi Ciutea-LeteaVeche, west of Chetriş-Gioseni villages and east of Valea Mică-Gheorghe Doja villages the load results from emissions dissemination and agricultural practices based on biological treated sludge fertilization, sludge supplied by the Bacău treatment plant or from treatments applied for pests and diseases.

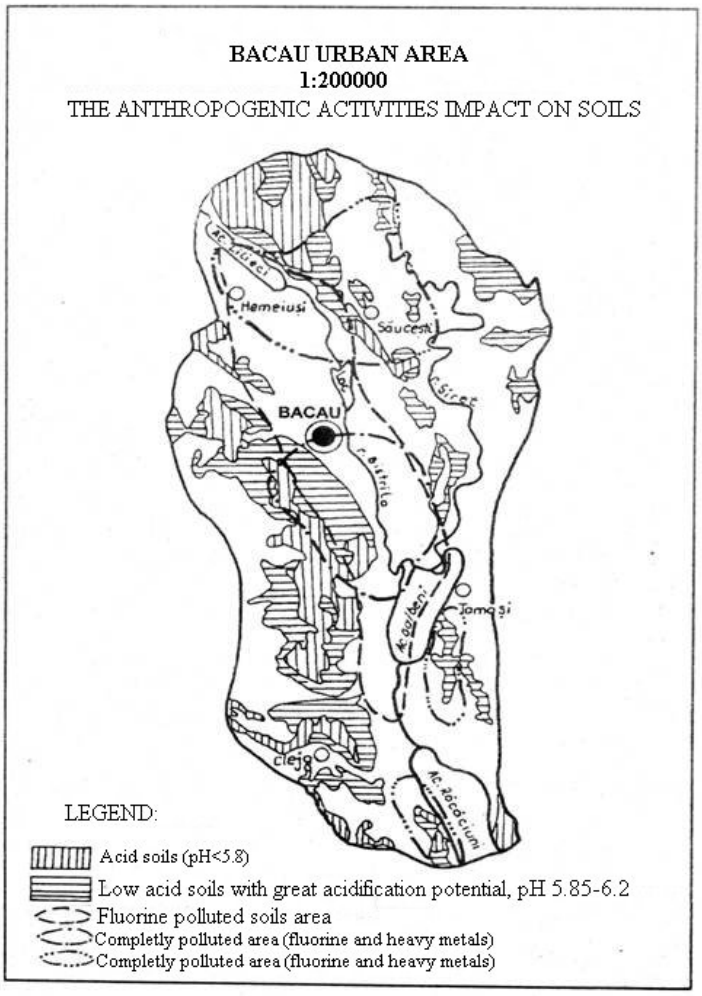

Figure 2.

In the area situated north from Bacău municipality, the pollution is enhanced mostly by the pollutants dissemination through the predominant southern winds and through the load given by the food industry nearby.

The HCH and DDT accumulations were tracked in 2 spots, on agricultural land, at 10 km from Bacău (in Nicolae Bălcescu) and north-east from Bacău (in Traian). While south of Bacău the organic-chlorine products have lowered constantly in concentration from 0,040 ppm HCH total and 0,039 ppm DDT total,

starting with the eighties, to 0,027 Valea Mică-Gheorghe Doja ppm HCH total and 0,001 DDT total in the Traian area the concentrations remained constant.

After 1989, in Romania and in Bacău city industrial production have decreased and undergone important structural transformations. Meanwhile some environmental measures were taken e.g. in Bacău where pollution lowered with 2/3 resulting in environmental quality improvement. Starting with 1995 until present a significant decrease appears for ammonia, dusts, nitrogenous oxides (up to $1/4^{th}$) and sulphur dioxide (up to$1/3^{rd}$). The acid rain parameters have ameliorated, their pH being between 6.0 and 6.8, and the ionic and salts content lowered. The joining treaties which Romania holds with the European Union require a 75% reduction for the pollution level until 2013. From 540.000 t of gaseous pollutants in 2004, Romania should come down to 143.000 t in 2013.

Even if these limitations exist, the present day pollution persists. The agricultural practices keep the pressure on because of intense usage of nitrogenous composts which have an acid physiologic reaction determining the soil structure degradation and accentuating the secondary soil compactness and supplementary amelioration costs.

The most polluted zone, in the studied area, is around the industrial platform, at the south of the city. Here you can have all the pollution types and at full intensity **(fig.2)**. This area covers 8 km from north to south and 6 km from east to west being centred on the industrial platform.

The present day absence of local and national interest for a productive agriculture and the agricultural practices studies limitation lead to a difficult general estimation of soil pollution. These studies represent an important condition for economic growth which should be based on systematic research of the environmental parameters.

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