ASSESSMENT OF WASTEWATER BIOSOLIDS MANAGEMENT OPTIONS AT REGIONAL LEVEL, USING GIS TECHNIQUES

EVALUAREA OPȚIUNILOR DE GESTIONARE A BIOSOLIDELOR LA NIVEL REGIONAL, UTILIZÂND TEHNICI GIS

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Abstract. *Wastewater biosolids are the byproduct from wastewater treatment process that contains nutrient – rich organic matter used in recycling and beneficial agricultural purpose. This paper aims to present the evaluation of biosolids management options at regional level, after the implementation of various wastewater and biosolids treatments by using GIS software package. The first analyzed solutions are biosolids field application as organic fertilizer and energy recovery by incineration or in industrial processes, depending on local conditions. Also, the factors taken into account for determining the suitability of agricultural lands to the application of biosolids are represented by land slope, soil pH and soil laden with heavy metals.In the new economy based on knowledge that is required in competitive societies, informational systems for organizing data becomes essential in decision making processes.*
Key words*: assessment, wastewater, biosolids, GIS, pH, heavy metals*

Rezumat. *Biosolidele reprezintă produsul secundar rezultat în urma procesului de epurare al apelor uzate care conține substanțe nutritive - bogate în materie organică, utilizate în scopuri agricole şi pentru reciclare. Lucrarea de față îşi propune să prezinte evaluarea opțiunilor de gestionare a biosolidelor la nivel regional, în urma implementării diferitelor metode de tratament a apelor uzate, prin utilizarea pachetului software GIS. Primele soluții analizate constau în utilizarea biosolidselor ca îngrășăminte organice pe terenurile agricole şi recuperarea de energie prin incinerare sau în procese industriale, în funcție de condițiile locale. De asemenea, factorii care s-au avut în vedere pentru stabilirea pretabilității terenurilor agricole la aplicarea biosolidelor sunt reprezentați de panta terenului, pH-ul solului si gradul de încărcare a solului cu metale grele.În cadrul economiei actuale, bazate pe cunoaștere, necesară în societățile competitive, sisteme informaționale pentru organizarea datelor devin esențiale în procesul de luare a deciziilor.*
Cuvinte cheie*: evaluare, ape uzate, biosolide, GIS, pH, metale grele*

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INTRODUCTION

Wastewater biosolids are the byproduct from wastewater treatment process that contains nutrient – rich organic matter used in recycling and beneficial agricultural purpose. It is one of the best sources of soil conditioner and source of slow release nutrients and microelements. For long term sustainable improvement of environmental quality factors by minimizing the adverse impacts of inadequate management of biosolids the development of a national strategy was required.

The main principle adopted in the development of biosolid management strategies at national and regional level, is to ensure, as far as possible, that the sludge is used as organic fertilizer or as renewable energy source.

The first analyzed solutions are biosolids field application as organic fertilizer and energy recovery by incineration or in industrial processes, depending on local conditions. Biosolids disposal in ecological landfills is always the last option and is recognized as unsustainable solution being subject to some legal restrictions in the European Union. In the new economy based on knowledge that is required in competitive societies, informational systems for organizing data becomes essential in decision making processes. Geographic Information System (GIS) develops more and more strongly, GIS is being applied in many areas of life, including agriculture.

MATERIAL AND METHOD

In accordance with national and EU policy, biosolids should be used beneficially through the most practical and efficient ways in order to avoid, as much as possible the disposal in landfills.

Potential methods of biosolids management in Romania consist of sustainable long term application of sludge on agricultural lands, on forestry plantations and lands rehabilitation, for energy recovery and through co-composting together with solid waste.This paper presents two methods of biosolids management at regional level, ie: agricultural use and energy recovery.

Agriculture. The factors that have been considered for determining agricultural lands suitability to the application of biosolids are: slope, soil pH, soil heavy metal load and biosolid quality (figure 2). For this study a GIS database was created, using ArcView, a GIS software package. One of the main shapefiles in the GIS database was the maximum permitted values for agricultural land application of biosolidsshapefile according to OM 344/2004. It was used Romania soil Map (scale 1:200,000) and EU reference dataset for land cover -Corine Land Cover 2000 (CLC200) (figure 1).

Energy recovery.The most used technology for energy recovery during the biosiolids treatment process is utilization of methane produced by anaerobic digestion process which generates heat and energy, called biogas.In the same database previously presented was created another shapefile representing potential locations in Romania for biogas production (figure 3).Other options for energy recovery from biosolids are incineration and co-combustion, made in cement factories and power plants.

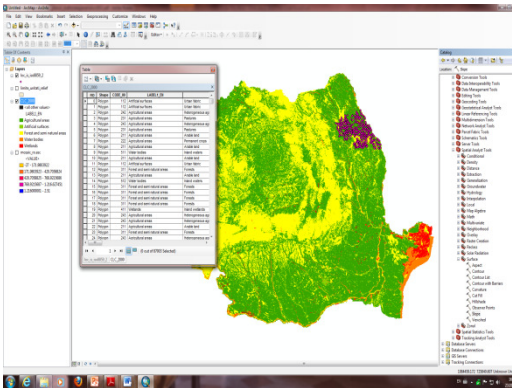

Fig. 1 - Corine Land Cover 2000 soil map

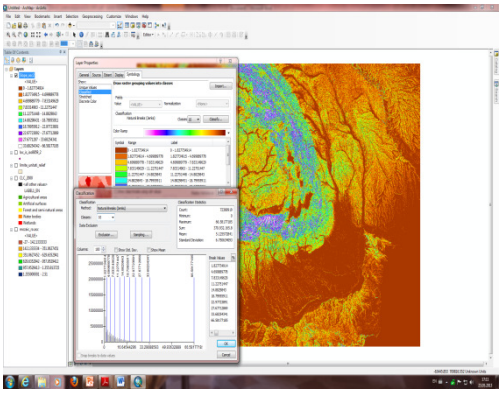

Fig. 2 - Creating terrain slope with Spatial analyst extension

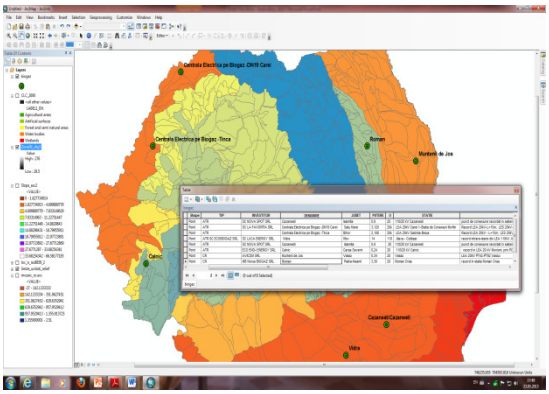

Fig. 3 -
Creating biogas shapefile in ArcMap

RESULTS AND DISCUSSION

The slope is closely linked to the protection of water sources due to potential risk for producing leakage in the case of heavy rains. Land with slope lower than 5% has the lowest risk, but OM 344/2004 allows biosolids application on lands with slopes up to 15% with conditioning that there are no additional risk factors.Table 1 present the assessment using GIS techniques of areas with slopes lower than 5% and 10%.

Soil pH strongly influences the mobility degree of heavy metals, by increasing or reducing the plants absorption. Romania chose a pH limit more restrictive than other EU countries and as result the biosolids can be only applied to soils that have a pH value of at least 6.5. EU Directive allows biosolids application on soils that have a pH>5.5, with the adjustment of maximum allowed heavy metal concentrations.Table 2 shows the evaluation results of arable land where soils pH is greater than 6.5.

Table 1

The share of arable lands with slope lower than 5% and 10% in each region

Region	Total area (ha)	Arable area (ha)	Arable land with slope < 5		Arable land with slope < 10	
			(ha)	(%)	(ha)	(%)
N – E	3685282	1219868	383114	31.4	1172689	96.1
S - E	3576047	1967166	1354854	68.9	1892508	96.2
S	3446639	2034674	1711345	84.1	1989435	97.8
S – W	2921483	1191866	900205	75.5	1153471	96.8
W	3203416	1010940	852107	84.3	974660	96.4
N – W	3416182	829800	423854	51.1	789796	95.2
Center	3408703	580550	241126	41.5	484022	83.4
Bucharest - Ilfov	180528	103855	93799	90.3	103844	100.0
Total	23838281	8938719	5960404	66.7	8560424	95.8

Table 2

The share of arable land with a soil pH greater than 6.5

Region	Total area (ha)	Arable area (ha)	Arable land with pH > 6.5		Arable land with pH > 6	
			(ha)	(%)	(ha)	(%)
N – E	3685282	1219868	811535	66.5	1046681	85.8
S - E	3576047	1967166	1856851	94.4	1910422	97.1
S	3446639	2034674	1374892	67.6	1769352	87.0
S – W	2921483	1191866	551415	46.3	881115	73.9
W	3203416	1010940	328281	32.5	602120	59.6
N – W	3416182	829800	222714	26.8	360327	43.3
Center	3408703	580550	307038	52.9	357454	61.6
Bucharest - Ilfov	180528	103855	5456	5.3	89085	85.8
Total	23838281	8938719	5458181	61.1	7016555	78.5

Given the multitude of sources of soil heavy metals load (industrial emissions, fertilizers, irrigation water, manure, etc.) and the fact that some sources can't be removed, being important links in the production process, it is necessary to limit their quantity. Whereare appliedbiosolidsshould be avoided fields that has reached a level of 80% of the maximum allowable load of heavy metal in soil. Loading the soil at a level above the maximum admissible limits leads to the pollution phenomenon manifested by decreasing the production, accumulation of heavy metals in plants, disorder of biological balance in soil, groundwater loading with heavy metals etc.

Figures 4, 5 and 6 shows the suitability criteria for biosolids land application depending on land slope, soil pH and heavy metals loads.

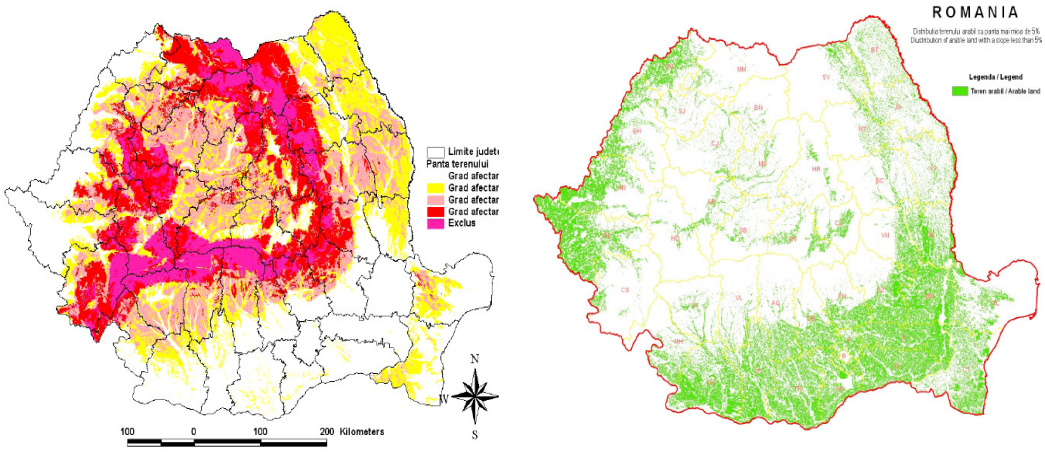

Fig. 4 - Suitability criteria for biosolids land application depending on slope

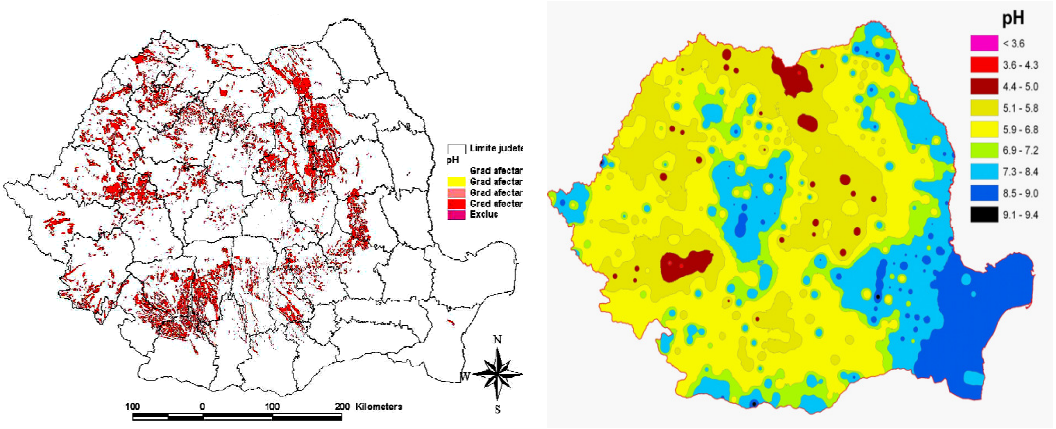

Fig. 5 - Suitability criteria for biosolids land application depending on soil pH

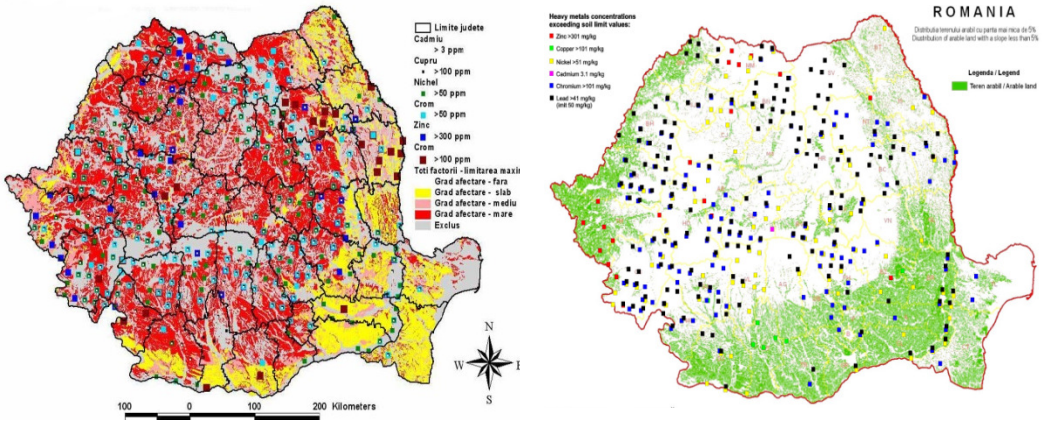

Fig. 6 - Regional distribution of heavy metals concentration compared to allowed values

CONCLUSIONS

The use of biosolids in agriculture is the most comprehensive solution. Regionally, data reflects that the number of areas where the land has a slope ≤10% and a pH≥6.5 are more compared to the areas that have a slope ≤5% and pH ≥ 6.5, especially in the regions NE, NW and Central. In the case of fields with a slope ≤ 10% where pH value was reduced to 6.0, suitable lands for biosolids application would increase both in the NW and SE, due to the presence in these areas of acid soils.

The use of biosolids for energy recovery will be made where feasible (technically and economically), but will not be widely adopted until 2020 because the landfill disposal costs are lower than those for co-processing in the cement factories.

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