STUDY ON ENVIRONMENTAL IMPACT OF THE CLOSURE OF THE TITU-DÂMBOVIȚA SOLID WASTE DUMP

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ABSTRACT - In the sustainable development context, waste management is seen as a major problem, which cannot be solved only by using technical means; a fundamental change is necessary in the current production, consumption and waste elimination pattern. Our study refers to the environmental impact of the closure of the urban Titu- Dâmbovița solid waste dump, and comprises: quality of the environmental factors, analysis of the size of the impact, evaluation of the potential impact on the environmental factors, evaluation of the global impact and post-closure monitoring of the waste dump. The results obtained concerning the value of the global pollution index and the bonitation grades for each environmental factor have led us to state that through the closure of this solid domestic waste dump, environment is affected within allowable limits, the impact is low and local, and the effects of this project on the environmental factors are positive.

Keywords: waste dump, Titu- Dâmbovița County, closure, environmental impact

1. INTRODUCTION

The Titu – Dâmbovița urban solid waste dump is situated outside the town, in the south, at the boundary with Odobeşti Commune. Operational since 1969, it has a surface of 7 ha, 12.756 m^3 of waste are deposited here annually, and the access is possible by using a specially-arranged road. This dump is used to store the domestic solid waste collected without previous selection from the population, domestic waste from the economic agents and waste produced by the town's services, without respecting the actual environmental protection principles, which results in a major environmental risk. According to the Governmental Decision HG no. 349/2005, the existing dumps that are not environmentally friendly cease their activity and apply the legal operation and monitoring provisions concerning their post-closure surveillance. We should recall the fact that the closure of this non-ecological waste dump will lead to the construction of a regional ecological waste dump in the same location, a waste dump that will respect the European standards and the Romanian legislation in force.

We must mention the fact that, to carry out this impact project, we have used analysis bulletins based on the gathering of samples out in the field by SC. GEOSTUD S.R.L. Bucureşti, on our demand, according to a contract concluded in this sense.

2. QUALITY OF THE ENVIRONMENTAL FACTORS

Soil quality. The storing system used at present is a partially organized one, large areas of the solid dump are uncovered, no previous selection of the waste takes place, so that beside the domestic waste, vegetal waste, textile and plastic waste, demolition waste, rubber waste and diverse kinds of

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industrial waste are also deposited. The main pollutants are organic and inorganic substances, heavy metal compounds, greases and oils, other industrial waste.

In order to determine the soil pollution level we compared the values obtained during the investigations carried out on the spot, followed by laboratory analyses, with the reference values mentioned in the legal norms (MAPPM[4] order no. 756/ 1997) concerning the soils with less sensitive use (Tables 1, 2, 3 and 4).

Table 1. *Soil sample S 1 (according to analysis bulletin no. 211/40)*

No.	Parameter	Unit of measurement	Value determined	Normal value	CMA	
					a.t.*	i.t.**
1.	pH	Unit pH	7.9	-	-	-
2.	Conductivity	S/cm	247.0	-	-	-
3.	Cadmium	ppm	4.4	1	5	10
4.	Copper	ppm	549.0	20	250	500
5.	Chrome	ppm	34.9	30	300	600
6.	Manganese	ppm	286.9	900	2,000	4,000
7.	Nickel	ppm	20.7	20	200	500
8.	Lead	ppm	63.3	20	250	1,000
9.	Zinc	ppm	501.0	100	700	1,500
10.	Oil products	ppm	66.0	100	1,000	2,000

*a.t. – alert thresholds for less sensitive soils
**i.t. –intervention thresholds for less sensitive soils
CMA = (Rom.) cantități maxime admisibile = maximum allowable quantities

Table 2. *Soil sample S 2 (according to the analysis bulletin no. 212/40)*

No.	Parameter	Unit of measurement	Value determined	Normal value	CMA	
					a.t.*	i.t.**
1.	pH	Unit pH	8.1	-	-	-
2.	Conductivity	S/cm	232.0	-	-	-
3.	Cadmium	ppm	3.8	1	5	10
4.	Copper	ppm	236.0	20	250	500
5.	Chrome	ppm	26.2	30	300	600
6.	Manganese	ppm	299.0	900	2,000	4,000
7.	Nickel	ppm	18.2	20	200	500
8.	Lead	ppm	48.0	20	250	1000
9.	Zinc	ppm	388.0	100	700	1500
10.	Oil products	ppm	46.0	100	1,000	2,000

*a.t. – alert thresholds for less sensitive soils
**i.t. –intervention thresholds for less sensitive soils

[4] Ministerul Apelor, Pădurilor și Protecției Mediului (Ministry of Water, Forests, and Environment Protection).

Table 3. *Soil sample S 3 (according to the analysis bulletin no. 213/40)*

No.	Parameter	Unit of measurement	Value determined	Normal value	CMA	
					a.t.*	i.t.**
1.	pH	Unit pH	7.7	-	-	-
2.	Conductivity	S/cm	132.0	-	-	-
3.	Cadmium	ppm	4.7	1	5	10
4.	Copper	ppm	510.0	20	250	500
5.	Chrome	ppm	34.4	30	300	600
6.	Manganese	ppm	388.0	900	2,000	4,000
7.	Nickel	ppm	30.2	20	200	500
8.	Lead	ppm	64.6	20	250	1,000
9.	Zinc	ppm	345.0	100	700	1,500
10.	Oil products	ppm	46.0	100	1,000	2,000

*a.t. – alert thresholds for less sensitive soils
**i.t. –intervention thresholds for less sensitive soils

Table 4. *Soil sample S 4 (according to the analysis bulletin no. 214/40)*

No.	Parameter	Unit of measurement	Value determined	Normal value	CMA	
					a.t.*	i.t.**
1.	pH	Unit pH	7.9	-	-	-
2.	Conductivity	S/cm	146.0	-	-	-
3.	Cadmium	ppm	4.2	1	5	10
4.	Copper	ppm	288.0	20	250	500
5.	Chrome	ppm	26.2	30	300	600
6.	Manganese	ppm	476.0	900	2,000	4,000
7.	Nickel	ppm	29.0	20	200	500
8.	Lead	ppm	62.0	20	250	1,000
9.	Zinc	ppm	183.0	100	700	1,500
10.	Oil products	ppm	106.0	100	1,000	2,000

*a.t. – alert thresholds for less sensitive soils
**i.t. –intervention thresholds for less sensitive soils

We collected as well a sample of levigated soil from a descent area with rain of water and then we analyzed is chemical laboratory results (Table no.5).

Table 5. *Sample of levigated soil (according to the analysis bulletin no. 209/40)*

No.	Parameter	Unit of measurement	Concentration determined	Norm concerning the allowed concentration
1.	pH	Unit pH	8.1	SR ISO 10523/97
2.	Biochemical oxygen demand CBO_5	mgO_2/dm^3	810.0	STAS 6560/82
3.	Biochemical oxygen demand CCO-Cr	mgO_2/dm^3	1032.0	SR ISO 6060/96
4.	Ammonia (NH^{4+})	mg/dm^3	286.0	SR ISO 7150-1/2001
5.	Nitrates (NO^{3+})	mg/dm	202.0	STAS 8900-1/71
6.	Total phosphorus	mg/dm	4.7	STAS 10064/75

The results concerning the soil quality show that we identified quantities above the allowed values for Cu, Cr, Pb, Zn, Cd and there appeared a content of Ni higher than the allowed limit, which suggests the possibility of soil pollution coming from galvanization muds or other types of industrial muds.

Air quality. The theoretical considerations on the fermentation gas emissions in the solid waste dump have been completed by concrete elements determined on the spot, which have shown that the Titu waste dump is not controlled, there is no collection of the fermentation gases and consequently there appears the waste self-ignition phenomenon; the waste is not covered daily, which leads to the appearance of unpleasant smells, and the access is quasi-free for people, animals and birds.

In order to estimate the volume and the flow of the fermentation gases produced, we took into account the total mass of the waste dumped (126,400 t), as well as the emission factor established (213m^3 /t dumped waste), the result being a total volume of the fermentation gases of 26,923,200 Nm^3 and a flow of 121 Nm^3 /h (Table no.6).

Table 6. *Fermentation gas volume and flow (waste dump)*

Waste dump	Mass of the dumped waste (t)	Total gas volume (Nm^3)	Fermentation gas flow (Nm^3/h)
			Year 2006
Titu	126,400	269,232,000	121

The estimation of the gas emission *content* took into account the fact that the dump is not covered and, consequently, the fermentation is mainly aerobic, leading to the production of carbon dioxide. In parallel, other gases appear as well, whose nature depends on several factors, out of which the organic components present in the waste, the temperature and the humidity of the environment can be mentioned. The investigations carried out on the basis of analysis bulletins *did not reveal* higher values than the accepted limit for sulfur dioxide, nitrogen dioxide, ammonia, and total dusts in suspension (Table no.7)

Table 7. *Gas emission content (according to the analysis bulletin no. 196/40)*

Period of mediation	Parameter	Unit of measurement	Value determined	Limit value	Margin of tolerance
1h	Sulfur dioxide (SO_2)	mg/m^3	0.081	0. 35*	0.150 mg/m^3 until January 1, 2004, then reduced by equal annual shares (%) to 0% until January 1, 2007
1h	Nitrogen dioxide (NO_2)	mg/m^3	0.067	0.2*	0.100 mg/m^3 until January 1, 2005, then reduced by equal annual shares (%) to 0% until January 1, 2010
30 min	Ammonia (NH_3)	mg/m^3	0.004	0.3*	-
30 min	Total dusts in suspension	mg/m^3	0.095	0.5**	-

* Order 592/2002 “Order of the Minister of Waters and Environmental Protection for the approval of the Norms concerning the limit values, threshold values and of the evaluation criteria and methods for nitrogen dioxide, dusts in suspension, lead, benzene, carbon monoxide and ozone emissions.”;
** STAS 12574/1987- “AIR IN PROTECTED AREAS – Quality conditions”.

At the same time, there appear CH_4 concentrations, with values under the allowed limits, but we must highlight the fact that the waste dump is not covered. Moreover, the lack of the protective vegetal cover to protect the surrounding area favours the dispersion of the pollutants in the neighbourhood and creates an obvious discomfort for the inhabitants who live nearby.

Water quality. The preoccupations related to water pollution used to focus in the beginning on the effects on man's health, while at present a growing concern is recorded about the effects of the polluted waters on the aquatic organisms and on the stability of water biocenoses (Duma, S., 2006).

The urban solid waste dump from Titu has an impact on the underground waters in the area, while the surface waters do not have to bear this impact because the rivers and rivulets are far enough from the dumpsite. However, there is a possibility that during the periods of significant precipitations, the formed torrents may wash the waste dumpsite and reach the neighbouring soil or the rivulets nearby, transporting quantities of solid waste and particles in suspension.

The investigations carried out based on analysis bulletins for the underground waters sampled in several different points show that the values of the analyzed indicators are under the maximum allowable quantities mentioned by all the legal norms that are now in force except for the Fe^{+2+3} and C^{+2} indicators (Tables 8 and 9).

Table 8. *Sample S 3- underground waters (according to the analysis bulletin no. 197)*

Features	**Values obtained**	**CMA**	**Indicators**	**Values obtained**	**CMA**
Appearance, colour, smell, taste	clear	acceptable	CCO- Mn (mgO_2/dm^3)	-	5.0
Turbidity (degrees SiO_2)	0	<=5	Sulphides and sulfurated hydrogen (mg/dm^3)	-	0.10
pH at 20^0	8.1	6.5 - 9.5	Residual free chlorine (mg/dm^3)	-	0.50
Conductivity (µS/cm)	1,840	2,500	Fixed residuum at 105^o C (mg/dm^3)	1,006.6	1,200
Hardness (measured in German degrees): total	35	minimum 5	Temperature (^{0}C)	20	-
Permanent	10.36				
Temporary	24.64				
Alkalinity (mva/dm^3)	p=0			m=7.3	

Table 9. *Sample S 3- underground waters (according to the analysis bulletin no. 197)*

Cautions	**Values obtained**		**CMA mg/l**	**Anions**	**Values obtained**		**CMA mg/l**
	mval/l	**mg/l**			**mval/l**	**mg/l**	
Calcium Ca^{2+}	9.5808	192.0	180	Nitrates NO_3	0.0419	2.6	50
Magnesium Mg^{2+}	2.9052	35.3	80	Nitrites NO_3	0.0021	0.1	0.50
Sodium Na^+	2.7512	63.2	200	Sulfates SO_4^{2-}	4.3722	210.0	

Potassium K^{+}				Bicarbonates HCO_3^{-}	8.8	536.9	
Ammonium NH_4^{+}	0	0	0.50	Carbonates CO_3^{2-}	0	0	-
Iron Fe^{2+3}	0.0100	0.28	0.20	Chlorides Cl^{-}	2.0310	72.0	250
Manganese Mn^{2+3}	-	-	0.050	Phosphates PO_4^{3-}	0	0	-
Total	15.2472	290.78		Total	15. 2472	821.6	

3. ANALYSIS OF THE SIZE OF IMPACT

Taking into account the analysis of the environmental factors, we notice that the impact of the closure of the Titu urban solid waste deposit will lead to a considerable improvement of the actual pollution process, and from the perspective of the landscape, considering the desolating images it offers at present, the impact will be an extremely significant positive one.

The method for assessing the impact on the environment comprises several stages of synthetic estimations, based on quality indicators that can reflect the general condition of the environmental factors under analysis. The quality of an environmental factor or element is estimated by transforming the qualitative aspects into quantitative measurements. Therefore, in relation with the effects' size we can determine indicators of quality (Iq): $Iq=1/\pm E$, where $\pm$ E is the size of the effect determined using the evaluation matrix. The determination of the effects by quantitative measurements (E) allows for their combination and reconciliation on a scale of the following type: + *positive influence; 0 zero influence; - negative influence.*

For the quantitative evaluation, the quality indicators of each environmental factor at a given moment are placed on a bonitation (manageability) scale, with the awarding of grades expressing how near or far from an ideal state these factors are (Table no. 10).

Table 10. *Bonitation scale for Iq*

Bonitation grade	**Iq = 1/± E; E ≠ 0**	**Effects on environment**
10	Natural environment	- environment not affected by the activity (project)
10÷9	Iq= (0÷0.25] E>0	- environment affected within the allowable limits - level 1 - the positive effects are significant (the sum of the positive effects is significant) - the activity generates a positive impact
9÷8	Iq=(0.25÷0.5]	- environment affected within the allowable limits - level 2 - the positive and negative effects compensate each other - the activity generates a low impact
8÷7	Iq= 0.5÷1]	- environment affected within the allowable limits - level 3 - the negative effects can be measured - the alert threshold is reached
7÷6	Iq=-1 E<0	- environment affected over the allowable limits - level 1 - the negative effects are significant - the intervention threshold is reached
6÷5	Iq= (-1.0÷-0.5]	- environment affected over the allowable limits - level 2 - the negative effects cause discomfort to life forms

5÷4	Iq= (-0.5÷-0.25]	- environment affected over the allowable limits - level 3 - the negative effects are obvious - the impact is important
4÷3	Iq= (-0.25 ÷-0.025]	- degraded environment - level 1 - the effects are damaging for long periods of exposure
3÷2	Ic= (-0.025÷- 0.0025]	- degraded environment - level 2 - the effects are damaging for medium periods of exposure
2÷1	Iq= under -0.0025 environment inadequate for life forms	- degraded environment - level 3 - the effects are damaging for short periods of exposure

Evaluation matrix for the environmental impact

The potential interactions or reactions between the effects of the project concerning the closure of the waste dump on the environmental components are measurable as "size of the effects $\pm$" using the matrix method. Based on the effects ($\pm$ E), we obtain the indicators of quality (Iq), on whose basis we find out the grades of bonitation (Gb) for each environmental element.

The value of the bonitation grades (Gb) indicates the extent to which the assessed environmental factor is affected (Table no. 11).

Table 11. *Evaluation matrix for the environmental effects*

Actions of the waste dump closure project	**Effects on the environment**						
	Under-ground waters	**Surface waters**	**Air**	**Soil and under-ground**	**Biodiversity**	**Landscape & cultural patrimony**	**Social & economic environment**
The influence of the dumpsite on the environment: -phreatic water level -the extent to which the area is affected	-	0	-	+	0	+	+
The assurance of the demands in point of construction for the closure of the dump -the covering system -used water storage and treatment -gas storage and treatment	+	+	+	+	+	+	+
Level of pollutant emissions in underground & surface waters and in the air: -systems for storing the emissions; -protection for the vegetation	+	+	+	+	+	+	+

Influence of the monitoring activity on the functioning of the protection systems in order to minimize the environmental risk	+	+	+	+	0	0	+
Social & economic effect	0	0	0	0	0	0	+
SIZE OF EFFECTS	+2	+3	+3	+4	+2	+2	+3

4. EVALUATION OF THE POTENTIAL IMPACT ON ENVIRONMENTAL FACTORS

The measurement of the potential impact of the waste dump closure project on the natural environment, in the area where the waste dump is situated, relies on the elements analyzed on environmental factors concerning the pollutant-generating sources, the estimated impact, and the condition of the natural environment. We calculated:

The environmental factor WATER
E UNDERGROUND WATER = + 2
I Q UNDERGROUND WATER = $\frac{1}{2}$ = + 0.50
Gb UNDERGROUND WATER = 8

Analyzing the bonitation scale, it results that the environment is affected within the allowable limits level 2; the positive and negative effects compensate each other; the activity generates a low impact.

E SURFACE WATER = + 3
I Q SURFACE WATER = $\frac{1}{3}$ = + 0.33
Gb SURFACE WATER = 8.65

Analyzing the bonitation scale, it results that the environment is affected within the allowable limits level 3; the positive and negative effects compensate each other; the activity generates a low impact.

The environmental factor AIR
E AIR = + 3
I Q AIR = $\frac{1}{3}$ = + 0.33
Gb AIR = 8.65

From the bonitation scale it results that the environment is affected within the allowable limits level 3; the positive and negative effects compensate each other; the activity generates a low impact.

The environmental factor SOIL + UNDERGROUND:
E SOIL + UNDERGROUND = + 4
I Q SOIL + UNDERGROUND = $\frac{1}{4}$ = + 0.25
Gb SOIL + UNDERGROUND = 9

From the bonitation scale it results that the environment is affected within the allowable limits level 1; the positive effects are significant (the sum of the positive effects is significant); the activity generates a positive impact.

The environmental factor BIODIVERSITY+ LANDSCAPE
E BIODIVERSITY + LANDSCAPE = + 2
I Q BIODIVERSITY + LANDSCAPE = $\frac{1}{2}$ = + 0.50
Gb BIODIVERSITY + LANDSCAPE = 8

Analyzing the bonitation scale, it results that the environment is affected within the allowable limits level 2; the positive and negative effects compensate each other; the activity generates a low impact.

The environmental factor SOCIAL + ECONOMIC
E SOCIAL + ECONOMIC = + 3
I Q SOCIAL + ECONOMIC = $\frac{1}{3}$ = + 0.33
Gb SOCIAL + ECONOMIC = 8.65

Analyzing the bonitation scale, it results that the environment is affected within the allowable limits level 3; the positive and negative effects compensate each other; the activity generates a low impact.

5. EVALUATION OF THE GLOBAL IMPACT

In order to simulate the pollutants' synergic effect, we have built an ideogram using the grades of bonitation obtained. Therefore, the ideal state was represented graphically using a circular surface, with rays that are equal to one another and have the value of 10 units of bonitation. By uniting the points resulted by placing on the diagram the values expressing the real state, we obtained an irregular geometric figure, with a lower surface, inscribed in the regulated geometric figure of the ideal state (Fig. 1).

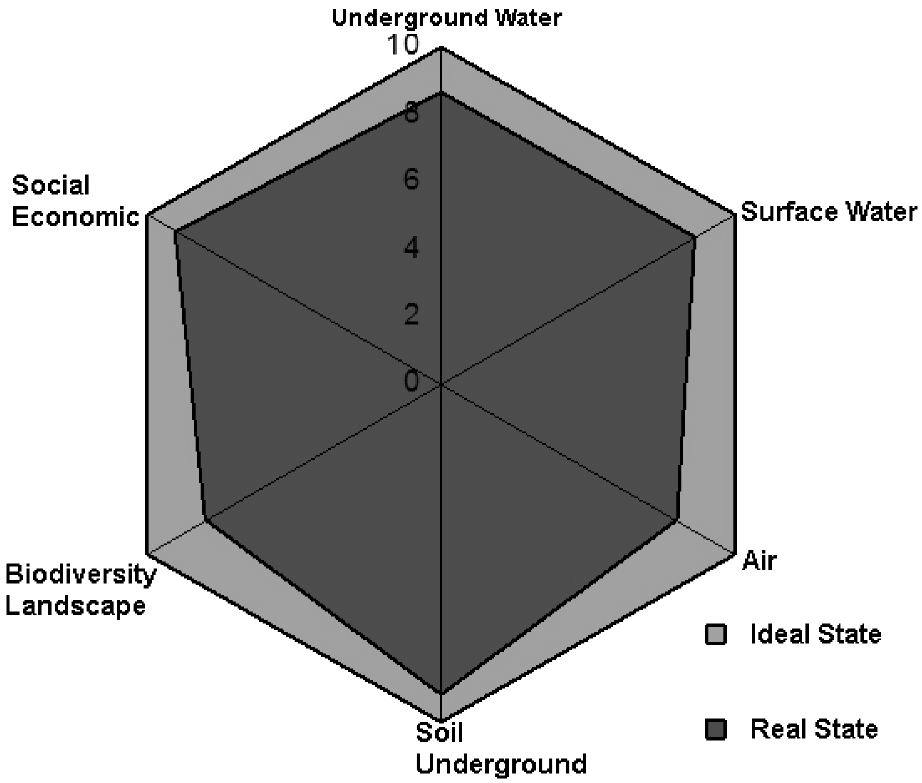

Figure 1. *Global impact*

The global pollution index (GPI) results by dividing the surface representing the ideal state (Si) to the surface representing the real state (Sr):

GPI = Si / Sr

We used an evaluation scale for the values of the GPI, from which it results the impact on the environment, namely the effect of the activity on the environmental factors:

GPI = 1 – natural environment not affected by the human activity

GPI = 1 ÷ 2 – environment submitted to the human activity effect within the allowable limits

GPI = 2 ÷ 3 – environment submitted to the human activity effect causing a state of discomfort to the life forms

GPI = 3 ÷ 4 – environment affected by human activity disturbing the life forms

GPI = 4 ÷ 6 – environment seriously affected by human activity

GPI over 6 – degraded environment, improper for the life forms

The calculation of the general pollution index (GPI) results from the built diagram, using the values of the bonitation grades (Gb UNDERGROUND WATER = 8, Gb SURFACE WATER = 8.65, Gb AIR = 8.65, Gb SOIL + UNDERGROUND = 9, Gb BIODIVERSITY+ LANDSCAPE = 8, Gb SOCIAL + ECONOMIC = 8.65) namely:

Si = 244

Sr = 214

GPI = 244/214 = 1.14

Taking into account this value of the GPI of 1.14, according to the principles established in the evaluation scale, we can see that the proposed activity, namely the closure of the analyzed urban waste dump, affects the environment within allowable limits, the impact is low and local, and the effect of this project on the environmental factors is positive.

6. POSTCLOSURE MONITORING

In compliance with the legal provisions in force, the operator of the Titu waste dump has to assure the post-closure monitoring for a period of at least 30 years; this period can be prolonged if, during the carrying out of the monitoring program, it is noticed that the dump is not yet stable and can present risks for the environmental factors and for human health. In case negative environmental effects are noticed, the operator of the waste dump is obliged to inform the competent environmental authority. The parameters that need to be monitored are those included in the legal provisions, including meteorological data, data on the emissions, on the underground waters and on the body of the dump. At the same time, in case the alert thresholds specified by the environmental authorization are exceeded, it will be necessary to urgently inform the competent authority, and this authority will determine the steps that need to be taken in order to prevent the deterioration of the environmental conditions in the area.

CONCLUSIONS

The impact study concerning the closure of the Titu - Dâmbovița urban solid waste dump has led us to the proposal of closing this dump, especially now, after the approval of the local authorities' project called "*Reabilitarea colectării, transportului, tratării şi depozitării controlate a deşeurilor solide din județul Dâmbovița*" (The rehabilitation of the gathering, transport, treatment and controlled storage of the solid waste in Dâmbovița County), worth 26 million euros, financed by the ISPA programme, concerning the building of an ecological dump in the same area by the end of 2009. This project's main objectives are to protect people's health, to improve the landscape conditions in Dâmbovița County by increasing the population's comfort in this area and the attractiveness of this area for tourists, and by reducing the use of resources by sorting out and recycling the waste.

The introduction of a new solid waste management concept in Dâmbovița County has in view the reduction of the large number of present dumps and the determination of the number of dumps necessary in future, through the adoption of zonal sorting and storing systems (North and South), well controlled from an ecological viewpoint.

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