

# REMEDICATION OF LANDFILLS ON THE ISLAND OF VIS BY USE OF EVAPOTRANSPIRATION ALTERNATIVE COVER SYSTEM

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*SUMMARY:* Official, but irregularly arranged landfills, which are used by the towns of Komiža and Vis are the subjects of remediation with the intention to be used over the next 5 years, when the start of operation for the regional waste collecting center, which will be on the land, is foreseen. The configuration and the manner of origin are similar for both landfills, which is also specific for the majority of Dalmatian islands. When choosing the manner of remediation, because of lack of material on the island for the instalation of a conventional cover system, and because of configuration of waste and specific climatic conditions, the use of evapotranspiration cover system made of locally available material was selected. This is a solution, which has so far not been implemented in the area of the Republic of Croatia. Therefore some guidelines for all of the similar unarranged landfills on Dalmatian islands can be set up now.

## 1. INTRODUCTION

Waste management in the former Yugoslavia and until several years ago in the Republic of Croatia too, has been performed in the majority of cases in such a manner that waste has simply been disposed of, without any control regarding its type, quantity and manner of landfilling. Thereby, landfilling sites have been selected a long time ago (not rarely as many as more than 50 years ago), when there was no knowledge and no developed awareness in responsible persons about the long-term negative environment impacts arising from inappropriately landfilled waste, yet. The basic conditions, that a potential site had to comply with, were the vicinity of landfilling site and its visual isolation, whereas any decrease of negative impacts coming from the emission of harmful substances on the environment and on humans had mostly not been considered at all. Because of the mentioned reasons during the siting, it is an often case that a large number of landfills are found on steep slopes, in natural and artificial depressions, hollows and round Karst valleys.

On the way to the European Union, the Republic of Croatia is performing the harmonization of its legal regulations with the EU legislation, by which it is obliged to upgrade its waste management system. One of the first steps leading towards this upgrading is the rehabilitation of the existing state. Apart from the rehabilitation, the Republic of Croatia Waste Management Strategy also proscribes the arrangement (restoration) with the purpose of continued landfilling

during the next 5 to 10 years. During that period, the implementation of regional waste management centers is foreseen, and after the opening of these, it will come to the final closure of the existing landfills.

A specific problem during the rehabilitation of municipal waste landfills represents the coastal area and the islands. In the area of almost the whole Croatian coast, and also on the islands, the forms of Karst relief predominate. A common feature of these areas is that they represent communities of labile ecological balance, which is because of its complex hydro-geological relations, whereby water circulation by way of cracks prevails, exceptionally sensitive for anthropogenic impacts. The mentioned areas are characterized by extremely steep, rocky and mostly bare slopes, numerous round Karst valleys and coves, whose lower parts have been turned to sea coves by sinking (Barbić and Barać, 2005).

Together with the legal obligations, which must by all means be complied with during landfill rehabilitation, it is necessary to also consider the specific qualities of each single site, as well as the limited economic potentials of the local community and local government organs, under whose competence the existing landfills are placed.

## **2. THE ISLAND OF VIS**

### **2.1 Basic characteristics of the island of Vis**

The island of Vis is one of the largest Adriatic islands: the tenth by its size, with a surface of approximately 90.3 km<sup>2</sup>. The maximum length of the island is approximately 17.5 km, while its width is approximately 7.5 km. The relief of Vis can be broken down over the length of the island into the three rolling directions among which two valleys are stretching. The highest peak of the island is Hum with 587 m above sea level. There are two towns on the island of Vis - Vis (1900 of permanent inhabitants and 114000 of tourist overnight stays) and Komiža (1700 of permanent inhabitants and 70000 of tourist overnight stays). It is evident that we are speaking about a sparsely inhabited island of an expressly tourist orientation, which means that during the summer months the number of people on the island significantly increases.

The island has two official landfills – Welington (for the town of Vis) and Šćeće (for the town of Komiža). Totally around 2000 tons of waste is being landfilled on them annually. Same as for the majority of island landfills, it is also characteristic for both of the Vis landfills that waste is being landfilled on the relatively steep slopes of the canyons, Karst valleys and coves, so that the access to some of their parts is very difficult.

### **2.2 Existing state**

#### *2.2.1 Šćeće*

The unarranged landfill of the town of Komiža, “Šćeće” is located at the western side of the island of Vis, southern of the town of Komiža, on a macadam diverging road for Stupišće, which diverges on its fourth kilometer from the old road Komiža – Vis. The very landfill stretches on the slope along the road in the length of approximately 500 meters, and it occupies a surface of approximately 10000 m<sup>2</sup>. The central part of the landfill is on the height of 170 m above sea level, and the sea coast is 600-700 m far from the landfill.

Waste from the town of Komiža has been transported to the site since 1960. It is estimated that currently around 25000 m<sup>3</sup> of waste is landfilled on the site, which is the result of degradation processes in the organic part of waste, but also of the fact that in the past, there have been outbreaks of fires on the landfill, purposefully set off or incidental, which have caused the

decrease in the volume of the landfilled waste. Of the 25000 m<sup>3</sup> of waste, around 12000 m<sup>3</sup> relate to municipal waste, which is landfilled behind the placed swing-gate, and the rest of waste is inert and bulky waste, which is being brought to the landfill by the population on their own initiative.

The slope inclinations of the natural ground, on which waste is being landfilled, are ranging from 1:4 to 1:6. At the site, waste is being tipped off from a plateau formed along the road, so that the landfill slopes are formed by free falling of waste. That is why these are very steep, having the inclinations of 1:1 to 1:1.5, and in some places even tension cracks are evident, as the consequence of collapse of the dumped material. The height of the dumped waste is not big and it ranges up to maximal 7 m.

The landfilled waste can be seen from the sea side from the nearby cove, in which the slope ends. Since the slopes of waste are not being covered by inert material because of steepness and inaccessibility, apart from its adverse impact on the underground and on the sea bed, the landfill has also an extremely negative impact on the visual aspect of the landscape.

### *2.2.2 Wellington*

The landfill site is on the northeastern coast of the island of Vis, approximately 5 km far from the Town of Vis. The site is approached by descending the asphalt road, and from there the landfill site can be accessed by an access road about 300 m long. The landfill cannot be seen from the main asphalt road, because of which this site has been primarily chosen at the beginning.

The landfilling of waste started back in 1963. At the beginning, waste has been landfilled in such a manner that it was tipped off directly from the access road along the natural slope of an approximate 1:4 inclination. In this way, waste has under the influence of gravitation taken its final position. In time, a plateau was formed on the landfilled waste, inclined by approximately 3 % towards the slopes. The plateau has grown as the time passed, so that its current surface is 0.65 ha. The total surface covered by waste is around 1.4 ha, while the total quantity of the so far landfilled waste was estimated to 110000 m<sup>3</sup>, taking in consideration that waste has partially been degraded, because of which initial volume has been decreased. Ten years ago, the building-in of waste started to be performed by means of a bulldozer, which pushes the waste tipped off to the edge of the plateau, wherefrom such waste, again under the influence of gravitation, is taking



Figure 1. Šćeće and Wellington landfill slope – side view

its final position. The slope inclination of the thus landfilled waste is around 1:1.5 (Figure 1). By this way of landfilling, a landfill body of a maximal height of around 20 m was formed, while the difference in the level between the highest and the lowest part of the landfill is even up to 35 m.

The body of the landfilled waste (waste slopes) can be seen from the sea side from the nearby cove, which is at a distance of about 1 km in a straight line. Since the waste slopes are not being covered by inert material because of steepness and inaccessibility, apart from its adverse impact on the underground and the sea bed, the landfill also has an extremely negative impact on the visual aspect of the landscape.

### **3. SO FAR PRACTICE IN MUNICIPAL WASTE LANDFILL REHABILITATION**

As it has already been mentioned, Croatia has, since several years ago, been performing the harmonization of its existing laws with the European Union laws. Among other things, new rulebooks concerning waste management, as well as Republic of Croatia Waste Management Strategy as the basic document, by which the Republic of Croatia guidelines and goals regarding waste disposal are defined, have been passed. One of the goals is also an as soon as possible rehabilitation of the existing landfills.

In Croatia, there are around 180 official and around 3000 wild landfills, on which approximately 70 million m<sup>3</sup> of waste have been landfilled, on a total surface of around 870 ha. On the majority of these landfills, not even the minimum proscribed environment and human health protection principles are being applied, so that these do not possess all the necessary working permits. The majority of the landfills having working permits have been rehabilitated during the past 6 – 8 years.

Looking at the manners, in which waste landfills have been rehabilitated until now, we can generally distinguish among three basic manners of rehabilitation, and these are:

- Covering of waste by the final cover system at the existing site;
- Waste excavation and its landfilling on another site, capable to receive certain types of waste, under the closure of the existing site;
- Waste excavation and its temporary landfilling, under the arrangement of a bottom sealing system at the same time, onto which the previously removed waste will be landfilled;
- Which one of the mentioned manners of rehabilitation will be chosen depends on a series of factors, as well as on their mutual relations, among which the most important are:
  - Site “sensitivity” for the emission of harmful substances from the landfill;
  - Types and quantities of landfilled waste;
  - Economic position of the local community, which finances the rehabilitation.

Apart from the mentioned factors, which influence the selection of the rehabilitation manner, it is necessary to satisfy the need of individual local communities for a continued landfilling on these landfills, because no alternative waste disposal solution exists in the near future.

The first step during preparing of documentation for rehabilitation of the existing landfills represents an Environment Impact Study, based on which the institution in charge will decide upon the acceptability of the proposed solution. Basically, none of the rehabilitation manners is able to completely satisfy all the requests, which are given as input parameters. The selected solution generally represents an optimum solution, which is often chosen based on a cost-benefit analysis.

Table 1. Medium monthly and annual temperature and precipitation (DHMZ, Komiža, 1981-2000)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ann.
Medium temp. (°C)	9.7	9.5	11.4	14.4	18.9	22.4	25.5	25.4	21.8	18.4	13.8	11.1	<b>16.9</b>
Medium precip. (mm)	65.1	64.1	54.8	52.9	26.6	37.8	21.4	26.8	52.6	51.4	95.3	99.6	<b>652.4</b>

## 4. PROPOSED SOLUTION FOR REMEDIATION

### 4.1 Selected cover system

Through their national legislation, the majority of European and world countries proscribes the use of conventional cover systems, whose action is based on the use the materials having a low water-permeability. So, until now, compacted clay layers (CCL) have been used most often for preparing of the conventional final cover systems. A correct functioning of barriers made of natural materials directly depends on the grade of material saturation, i.e. material permeability is increased with the decrease of water share. If it comes to humidity decrease over a shorter period of time, the appearance of cracks in the barrier is probable, and then it comes to a significant increase of hydraulic permeability of the built-in material. This problem is especially prominent in the areas featuring dry and semi-dry climates.

Apart from CCL, artificial materials (geomembrane or GM and geosynthetic clay liner or GCL) are also often used for covering. However, artificial materials are used in combination with other natural materials and their contact places represent potential sliding planes. That is why the use of individual artificial materials is limited by the maximal waste slope inclination, which is being covered. Maximum slopes up to 1:3 are used the most often.

Because of the mentioned shortcomings of the conventional cover systems, the possibility for the use of alternative cover systems, in which the mentioned problems are less prominent, has been considered. The work of the alternative cover systems is based on the potential that the material retains (accumulates) as large as possible quantities of water, until it is eliminated in the atmosphere by transpiration and evaporation. So the main reasons for the use of ET cover systems for landfill rehabilitation on the island of Vis are:

- Climatic characteristics of the area;
- Material available on the island (terra rossa);
- Waste configuration.

In Table 1, the basic climatic characteristic of the island of Vis (medium precipitation and temperature values) are shown. Apart from temperature and precipitation, wind is also playing an important role in the functioning of ET cover systems. An especially interesting wind is the so called "bora" or north-western wind, which starts to blow mostly after precipitation and thus increases the total evapotranspiration over a short period after precipitation cessation and thus also decreases the possibility for leaking of accumulated water into waste.

### 4.2 Geometry of rehabilitated landfills

#### 4.2.1 Wellington

One of the basic criteria during the selection of the final landfill geometry was the minimization of excavation and of the total final surface covered by waste, as well as a permanent stability of waste and the cover system. The existing waste slope inclination is from 1:1.25 to 1:1.7, while the plateau inclination, from where waste is being landfilled, is between 3 and 8 %. The existing slope inclinations do not ensure a satisfactory permanent stability of the cover system. Namely,

the shear strength of the built-in material depends on the material type and the building-in conditions. Since the material compactness is restricted by technical conditions of material building-in for the ET cover system, the strength parameters (internal friction angle and cohesion) will also be less than the maximum ones.

The waste, which is found outside of the final surface foreseen to be covered, will be shifted to the existing waste slope toe and a slope, having the final inclination of 1:2, will be formed. On the waste shaped in such a manner, the final cover system, with the following components, will be built-in:

- Leveling layer of fine-grained material, d=15 cm
- Layer of coarse-grained material – capillary break, d=20 cm
- Fine-grained material (for water accumulation), d=100 cm
- Surface layer, d=20 cm

In order to increase the cover system stability, a geo-net will be placed in the central part of the fine-grained material layer. The network will be anchored in the waste on the plateau, and in this manner a part of the force will be transferred from the cover to the waste on the plateau. On the landfill perimeter, construction of a canal for precipitation water collection is foreseen. The canal will also be executed on the edge between the plateau and the landfill slope. The characteristic cross-sections of the existing and the designed state are shown in Figure 2.

#### 4.2.2 Šćeće

Because of the restricted space, the aim of the remediation is to minimize excavation and the size of the new, rehabilitated landfill. The area, which is now covered by municipal waste (the part below the swing-gate), will be completely excavated and the waste will be removed to a newly arranged sanitary cell, which will be formed on the slope below the road.

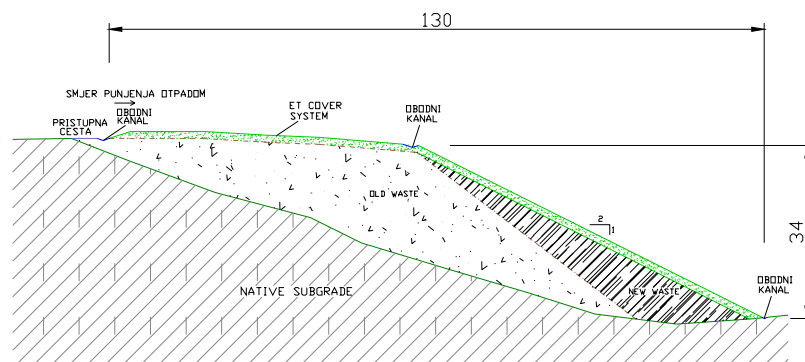


Figure 2. Cross-sections of the existing and the designed state

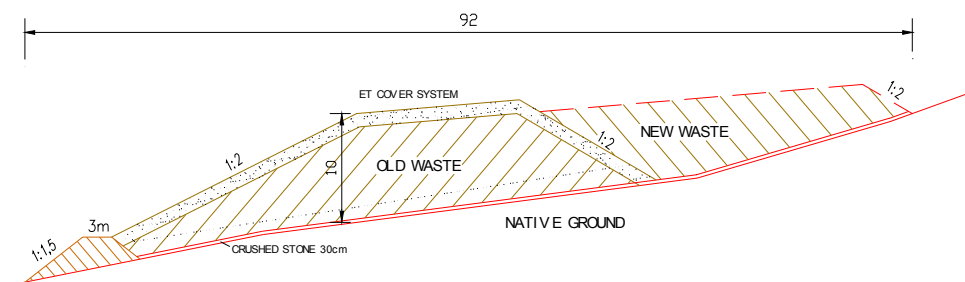


Figure 3. Cross-section of the designed state

Table 2. Parameters used for HELP calculation and calculation results

	Type of material	Thickness (cm)	Porosity (vol/vol)	Field capacity (vol/vol)	Wilting point (vol/vol)	Sat. hyd. conductivity (cm/sec)	Average infiltration (mm/yr)
Conventional	Loamy sand	15	0.437	0.105	0.047	0.0017	108.63
	Compacted clay	80	0.451	0.419	0.332	$6.8 \cdot 10^{-7}$	
ET	Silty loam	20	0.501	0.284	0.135	$1.9 \cdot 10^{-3}$	118.43
	Silty loam	100	0.501	0.314	0.145	$1.9 \cdot 10^{-4}$	
	Gravel	20	0.397	0.032	0.013	0.3	

The area above the swing-gate, in which mostly inert waste is found, will be cleared on the surface from bulky waste, and the inert waste from the site will be used as the building material for the new landfill.

The new cell for sanitary landfilling has a triangular layout and it spreads towards a lower elevation of the field, in the sense of a better use of the available space. The receiving cell is a cleared natural ground, covered by a drainage layer of stone material  $d=30$  cm, having the inclination of the natural terrain from 1:4 to 1:6.

The covering layer is a same evapotranspiratory cover layer (combination of natural materials and autochtone vegetation) proposed for Wellington.

The inclinations of the covering layer are:

- In the transversal direction 5%, single sloped, towards the peripheral canal, at the end a slope of 1:2 is formed, which is also the edge of the peripheral canal;
- In the longitudinal direction – the fall of the terrain is followed to the cross-section 6-6, and the lower part of 1:2 to the embankment.

At the lower edge of the cell, an embankment made of stone material is formed having a slope inclination of 1:1.5 and the crown width of 3m, which has two functions – it serves as a support to landfill body stability, and also as a traffic connection for the needs of landfill maintenance.

For the access to the landfill, the newly constructed macadam access road (serpentine) will be used, which diverges from the existing earth road on the embankment. The access road is executed having a width of 4m with a widening in the curve, and it ends with a turning point having a diameter of 15m.

The foreseen capacity of the new landfill is ca 20000 m<sup>3</sup>, whereby excavated waste quantities are encompassed, as well as the new quantities over the next 5 years, until the construction of a transfer station and a regional center. During the first phase, the body of the old waste, which is covered by ET layer, is formed on the prepared base in the lower part of the cell. In the second phase, the other part of the cell is being filled with the new waste, which will in the course of the final shaping be also covered by ET layer.

## 5. COVER SYSTEM DESIGN

### 5.1. Cover material

Based on the meteorological data collected from the nearest meteorological station (Table 1) and based on the supposed characteristics of the materials to be built in, a numerical simulation of precipitation water infiltration through the covering systems was performed. The following covering systems were observed:

- Conventional (surface layer  $d=15$  cm, clay barrier  $d=80$  cm)
- ET-1 (surface layer  $d=20$  cm, fine-grained material  $d=100$  cm, coarse-grained material –

capillary break, d=20 cm, leveling fine-grained material layer d=20 cm)

The fine-grained material, which will be used for the implementation of ET system, is the locally available terra rossa (Matjašić, 2005). It is brown-red silty clay with smaller fragments of the basic rock. Calculations have been conducted by the use of the Visual HELP computer program (Waterloo Hydrogeologic Inc, Version 2.2, 1997-2004.). Absolute quantities of water infiltrated through an individual cover system were not observed as the result, but infiltration quantities through alternative cover systems were compared to the conventional systems at the level of a ten year average. Since the use of the ET cover system is not regulated by the existing laws, it was essential to show that the proposed cover system will have a smaller or approximately the same infiltration, as the conventional cover systems. Based on the results of the calculation, the use of the ET cover system was permitted for the rehabilitation of the landfills on the island of Vis.

Material parameters, which were used for numerical infiltration simulation, as well as calculation results, are shown in Table 2.

Within the project, some technical conditions for material building-in have been given. In order to make the development of vegetation possible, which has an important role in a proper functioning of a possible ET system, and to ensure sufficient capability of the built-in material for water accumulation, the most important thing was to define the maximum material density after building-in.

The maximum density is defined as 87 % of the maximum density from the standard Proctor test on the dry optimum side. In order not to exceed the required compactness, the use of the compacting equipment of a maximum 4 t mass, under the building-in of the material in layers, 30 cm thick, is proscribed.

Before the start of the implementation of the cover cell, a trial cell will be implemented, where the necessary numbers for passing of mechanization will be determined for the purpose of the achievement of the required compactness, and the layer thickness, in which the material is being built-in, will be changed, as necessary.

## **5.2 Vegetation**

The final works on the landfills of Šćeće and Welington relate to the planting on the very landfill body, i.e. biological rehabilitation. Apart from the aim for the landfill to optimally fit in the broader spatial context, the function of the selected vegetal species is to contribute by evapotranspiration to an as quick as possible decrease of water quantity in the cover system. Certain analyses and tests must precede this, in order to establish certain indispensable input parameters for the biological rehabilitation project.

Otherwise, the very procedure of habitat recultivation, i.e. biological rehabilitation represents an insufficiently affirmed subject matter in the Croatian expert and scientific/research work. Most often, papers with these topics refer to the establishment of the basic theoretical postulates, and most frequently, it does not come to any implementation because of relatively high costs (the need to import seedlings).

In Croatia, the notion of recultivation mostly refers to quarries and material borrow-pits, and a certain literature concerning these areas exists (Scientific-expert Meeting, 1996). These basic principles can also be taken over for landfill body rehabilitation, since it is the question of surfaces, which should be renaturalized, i.e. extensively planted. Thus the choice of planting material depends on:

- Geographical position of the landfill;
- Autochtone climatic-ozone phytocenosis;
- Climatic conditions;

- Geological – pedological circumstances (physical and chemical soil properties);
- Technical conditions at the landfill (slopes, level of fertile ground layer, ...);
- Biological – ecological properties of species;
- Possibility to ensure or purchase the planting material (seeds and plants). The best way is to foresee forest seedlings, since they are smaller – they are prepared more easily, and they are more resistant.

With regard to the above said, the first step is an analytical one; site visit on the field and establishment of the autochthonic climatic-ozonophytocenosis, which has been done during the procedure of the preparing of an Environment Impact Study for the mentioned locations. Among the totally determined plant material, species in the category of semi-bushes, bushes, smaller trees, as well as climbing and creeping plants, as well as those which are at the same time evergreen, are interesting for the procedure of recultivation.

The island of Vis has as regards the essential characteristics, the same climatic conditions as the so called belt of evergreen holm-oak forests (*Quercus ilex*). For this belt, the coastal climate with summer droughts of an average duration of three months is important. Although during this period plants are getting some humidity, which is given by the sea to the inland, the drought is still during the hottest daily hours so big that during that time even assimilation stops. The vegetation period is mostly not interrupted by the winter. Many species are flowering and bringing fruits during the winter (*Viburnum tinus*, *Phillyrea latifolia* etc.).

The most characteristic among all of the plant communities is the so called garigue, in which the predominant role is played by the bushes of rock-rose (*Cistus monspeliensis*, *C. villosus* and *C. salvifolius*) (Kulić, 2005).

The area around the landfill belongs as regards vegetation to the forest of Aleppo pine and holm-oak (*Quercus ilex*–*Pinetum halepensis* Loisel 1971). This mixed forest of a characteristic appearance with holm oak in the underneath layer and the dominant Aleppo pine is very common in the Mediterranean and it is also spread over the Middle Dalmatian islands. As it happens, Aleppo pine is spreading alone from the cultivated cultures to the neighboring surfaces in the broader area.

In the natural stands, Aleppo pine is growing in the dominant layer and the species are developing exuberantly underneath: in the layer of bushes *Quercus ilex*, *Pistacia lentiscus*, *Viburnum tinus*, *Myrtus communis*, *Smilax aspera*, *Rubus discolor*, *Ruscus aculeatus*, *Juniperus macrocarpa*, *Juniperus oxycedrus*, *Asparagus acutifolius*, *Rubia peregrina*, *Pistacia lentiscus*, *Arbutus unedo*, *Phillyrea angustifolia*, *Phillyrea latifolia*, *Juniperus phoenicea*, *Juniperus oxycedrus*, *Olea silvestris*, and the accompanying: *Erica multiflora*, *Cistus saviifolius*, *Cistus monspeliensis*, and in the low plant cover *Brachypodium ramosum*, *Dorycnium hirsutum*, *Teucrium montanum*, *Teucrium polium*, *Helichrysum italicum*, *Cyclamen europaeum*, *Euphorbia spinosa*, *Mercurialis annua* and others.

Apart from the criterion of autochthony, we are also mentioning the other criteria, which are essential for the so called alternative cover system: it is essential to choose such species, which are tolerant to drought, soil texture, with good transpiration characteristics (high coefficient of transpiration, both during the cold and the warm season of the year), adequate root depths, resistant, long-lived, competitive as regards root vegetation, resistant to erosion (ITRC, 2003).

The majority of the mentioned species is suitable for planting on the landfill body, which we can divide in two basic categories:

#### 1. Upper landfill plateau

Bushes and semi-bushes: *Viburnum tinus* L., *Cistus salvifolius* L., *Arbutus unedo* L., *Teucrium polium*, *Lavandula spica*, *Pistacia lentiscus*, *Pistacia terebinthus* L., *Phillyrea angustifolia*, *Cistus monspeliensis* L., *Rubus* sp., *Quercus ilex* L., *Ceratonia siliqua* L.

#### 2. Landfill slopes

*Juniperus oxycedrus L., Erica multiflora L. Rosmarinus officinalis L. Juniperus phoenicea L., Lonicera implexa Ait., Clematis flammula L.*

In the procedure of biological rehabilitation, the basic prerequisite is to ensure a sufficient quantity of quality fertile soil. This is, however, not easy under the conditions of the Mediterranean Karst, where lack of fertile soil is present. It is necessary to ensure a layer of fertile soil of a minimum of 30 cm. A surface layer of 20 cm would be applied on it (a mixture of fine-grained and coarse-grained materials), while at the very place of planting the thickness of this layer of 5-10 cm is proposed (Scientific-expert Meeting, 1996). Beneath this layer of fertile soil, silty clay 70 cm thick is placed, so that the total thickness of the layer for water accumulation would be 100 cm. Plants are set out in rows, in the so called triangle arrangement, in order to overgrow the surface as much as possible.

## **6. MONITORING**

The basic goal of monitoring is to ensure a long-term correct functioning of the installed systems, because only their functioning can safeguard for the required environment protection (ITRC, 2003).

The simplest manner for the control of the installed cover system is visual inspection. Since immediately along the rehabilitated site, a cell for continued landfilling will be arranged, the personnel, who manage the landfill, will be responsible for implementation of a visual control for the cover system. The basic goal of the visual control is the recording of possible damages in the cover system, i.e. the establishment of system integrity. The most often causes of damages are erosion and excessive settlement of waste. At the landfill site on the island of Vis, conducting of visual inspection every month during the use of the landfill (5 years after rehabilitation) is foreseen. After that, it is foreseen to conduct the control every 6 months. The control will also be performed after profuse precipitation.

The monitoring of the planted vegetation relates to the check-up of their growth conditions, as well as a possible exchange of the perished vegetative material, i.e. the performing of the basic phytosanitary protection. However, since the selected plant material is in line with the phytocenosis of the area, it should be expected that after a certain time the natural succession will start, i.e. spontaneous return of the natural state to its peak, the climax

Apart from the visual control, the building-in of two lysimeters for a direct measurement of water quantity infiltrated through the cover system is foreseen.

## **7. CONCLUSION**

The Croatian coast and the islands have a predominantly Mediterranean climate (moderate quantity of precipitation, temperature, wind), and for that reason they represent potential areas for the use of evapotranspiratory systems for the covering of waste. The basic problem, by which the use of ET systems in the mentioned areas is restricted, is a possible lack of locally available material for the implementation of the system. Another problem the designer is confronted with is non-existence of legislation, by which the use of ET cover systems would be regulated, i.e. lack of experience with similar cover systems in persons with those institutions, which are relevant for acceptability evaluation of the selected rehabilitation project.

Rehabilitation and final covering of waste on the island of Vis represents the first project in the Republic of Croatia, where the ET cover system is being designed. The necessary consents for the approval of the selected manner of rehabilitation have been obtained from the institutions in charge, based on the numerical activity simulation of the conventional cover systems

(regulated by law) and the designed ET cover system. Additional data on system functioning will be gathered within the framework of the obligatory monitoring and they will represent valuable input data for the designing of the future covering systems. The gathered experience represents the first step in a broader use of ET cover systems for the rehabilitation of a large number of unarranged insular and coastal landfills.

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