IZMIR PRIVATE CAKABEY SCHOOLS

A BRAND-NEW APPROACH TO PLANTATION IN BOZALAN CLAY

STUDENT CLASS PROJECT

Students İnvolved:Tuan Dolmen,Defne Sallı,Arda Derbent,Arda Çağan Karagöz,Berke Korkmaz,Polen Light,Belkıs Aysu Özbek, Doruk Sertkahya,Yaman Efe Mertoğlu

Supervisors: Viki Kalderon-Fulden Ulucan

2018-İzmir/TURKEY

CONTENTS

ABSTRACT

As İzmir Private Çakabey Schools Project Club students, we attended the Quarry Life contest with our innovative idea for the Bozalan clay quarry. Despite being very rich in clay reserves, biodiversity is low in this area. In our club studies, we have decided that both vertical and horizontal plantation will be the most effective method to implement to ensure succession. Vertical planting (gardening) is an innovative technique that allows stone walls or dry surfaces to be turned in to green and living areas. The naturally layered structure of the region is very suitable for such an application. We started to our studies by digging deep holes in the horizontal layers, and filling them in with fertile surface soil. Each were planted with Maqui tree samplings, that are the natural plant type of the climate there. The vertical surfaces were covered with felt which is a landscaping material and were planted vertically. In our preparatory field studies, we provided the seeds of Mediterranean medicinal plants which is the naturally occurring plant type of the area and we planted the seeds between the two layers of felt homogeneously and we stabilized the seed-filled felt on the vertical surface. We performed watering by natural ways or drip irrigation method throughout the system. Thus we ensured that the felt dampened and the medicinal plant roots grew between two felt layers. We provided the mixture of nutrients that plants were needed, via the same system. Within the scope of the project, for the horizontal gardening area of 40 m^2 and the vertical gardening area of 30 m^2 we carried out our studies with a total cost of 2290 TL. Growth success was 100% in horizontal gardening while it was about 46% because of some problems arising from drip irrigation system. As a result we demonstrated that biodiversity of this area could be increased by medicinal plant species grown up successfully in our project.

Key Words: Vertical Gardening, Clayquarry, Mediterrenean medical plants, Biodiversity

1. INTRODUCTION AND AIM

Mankind buried under concrete and barren lands, remains unconscious of the fact that each and every detrimental move made towards the aim of using natural areas for industrial applications cause massive damage for indigenous plants (1). This major problem eventually turns out to be a big obtacle against plant diversity or even biodiversity as a whole (2). One of the applications, quarrying activity is a necessity that provides various materials used in many structures. However, like any other anthropogenic factor, quarrying activities have significant impact on the nature (3).

As İzmir Private Çakabey Schools Project Club students, we attended the Quarry Life contest with our innovative idea for the Bozalan clay quarry. As is known, self-repair of a damaged and completely ruined area in the nature is a very long and difficult process.In active quarries, very large barren lands form. In these areas, which are open to erosion and landslides, the most important obstacle against the biodiversity augmentation is the inability to hold the necessary nutrients and water for the plants. Thus, the risk of erosion and landslide is fairly high (4).1.7 million tons of clay is extracted annually from Bozalan clay quarry. The mining area is 99.27 hectares and the surrounding land is forested. Although clay reserves in this area are very rich, biodiversity is low. The main flora of the region, which has Mediterranean climate conditions, consists of maquis plants (5).

Figure 1. Bozalan Clay Quarry and Akçansa Cement Plant

In our project, it is aimed to increase biodiversity by using medicinal plants suitable for Mediterranean climate, by applying different horizontal and vertical gardening models around the Bozalan clay quarry, which has a natural layered structure.

The natural layered structure of the area is highly suitable for this kind of planting. Horizontal parts of the layered structure shall be filled with fertile surface soil by opening deep pits and vertical planting shall be carried out on the vertical walls covered with felt, a special landscape material.Felt (geotextile) has become a product which is demanded in the industry and daily life, due to the properties it has such as: lack of harmful materials in its structure, heat resistance, liquid repellent characteristic and price reasonableness (6). Thus, medicinal maquis types which overlap the climate of area could be planted in each gardening model. The maquis is a shrub vegetation in the Mediterranean region, with broad-leaved, evergreen trees and consists of types such as: *Cistus spp., Quercus coccifera, Arbutus unedo, Nerium oleander* (7).

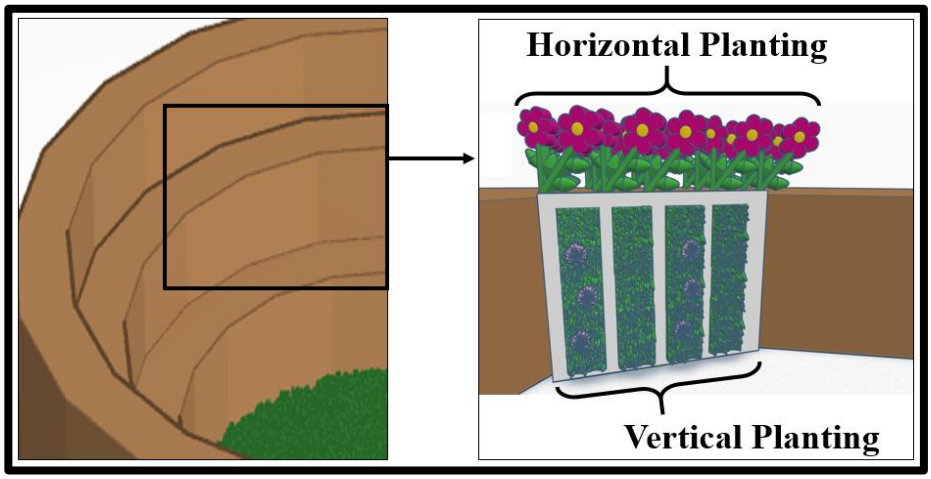

Figure 2. Schematical demonstration of horizontal and vertical gardening

The biggest threat in horizontal gardening is the goats in the region. In our project, the area has been protected by using razor / barbed wire to prevent the goats from entering the gardening zone.Vertical gardening is an innovative technique that allows stone walls or dry surfaces to turn into green and habitable areas. The vertical gardens firstly applied by the French botanist Patrick Blanc in 1988 create an interesting landscape arrangement (8, 9). The garden design is based on growing vertical and soilless plants on a suitable wall. While vertical gardening having a vital importance in terms of converting an area full of urban concrete walls into an aesthetic, healthy and habitable area; Turkey does not have yet a lot of vertical gardening applications (10).

In our research, it has been observed that plants can survive in some materials with external mineral supplementation. In order to grow the plants on a vertical surface, an irrigation system capable of providing water across the fabric layer is needed (8). The felt material (geotextile) used in the produced vertical gardening model is suitable to provide a soil-like ground which plants can root.The raw materials of geotextiles are thermoplastics (11).Geotextile is made of 100% polyester or polypropylene fibers. Polyester-made geotextiles have higher deformation modulus, tear resistance, temperature resistance, sunlight resistance and yield limit than polypropylene-made geotextiles (12).

In horizontal gardening model, irrigation is provided with rain, whereas in vertical gardening watering will be provided with drip irrigation pipes placed in the system besides rain. So the felt will be moistened and the roots of medicinal plants will sprout and grow in the felt layers. In addition, the system can be supplemented nutritionally via drip irrigation. As a result, hardwork will ensure the greening of the clay quarry and the rehabilitation of biodiversity.

Since plants are the basis for the ecosystem as producers, plant succession has been targeted in our project. In an ecosystem, food production begins with plants and the energy obtained is transferred to other organisms in the food chain. For this reason, if we aim to increase biodiversity and provide habitat for species, we must develop strategies that will provide suitable areas for plant succession (13). With the provision of planting in the field, animal diversity will be increased as well. Bees, helicopter bugs and other species that play an important role in pollination will positively impact general succession, thanks to their high reproductive potentials and their genetic diversity (13). The plant species will be carefully chosen, so that they will not face the danger of being eaten by the goats like the ones before. We believe that the diversity in the area will increase gradually as the area becomes more balanced chemically, physically, and biologically.

2. MATERIAL AND METHOD

The felt to be used in our project is a non-woven geotextile, which is produced by needle-punching of polyester (PES) or polypropylene (PP) fibers, and is a permeable cover used for drainage separation, filtration and protection(14). We learned from our preparatory studies that the naturally grown plants around the clay quarry are mediterranean medicinal plants. From the felt materials given in the Table 1, we used the one that is thinnest and has the least amount of polyproplene in it. Thereby we aimed to shorthen the time required for felt to dissolve in nature

Table.1. Properties of geotextilematerial (15)

GEOTEXTILE PROPERTIES (FOR FILTRATION AND SEPERATION PURPOSES)								
	TEST METHOD	UNIT	STATS					TOLERANCE
RAW MATERIAL	POLYPROPYLENE (PP)							
UNIT WEIGHT	EN ISO 9864	g/m²	150	200	250	300	400	-%10
WIDTH	EN ISO 9863-1	mm	1,00	1,00	1,50	1,70	2,50	-%10
TENSILE STRENGTH	EN ISO 10319	kN/m	8/10	11/13	13/15	17/19	21/23	-%10
ELONGATION AT BREAK	EN ISO 10319	%	50	50	50	50	50	-%10
STATIC PUNCTURE RESISTANCE	EN ISO 12236	N	1500	2000	2500	3000	4000	-%10
DYNAMIC PUNCTURE RESISTANCE	EN ISO 13433	mm	26,00	24,00	20,00	16,00	8,00	+%10
LIQUID PERMEABILITY	EN ISO 11058	m/s	0,06	0,07	0,06	0,05	0,04	+%10
PORE GAP	EN ISO 12956	Mm	0,13	0,13	0,12	0,12	0,11	+%10
DURABILITY	EN 12224	%	70	70	70	70	70	-%10

2.1. First Experiments at the School Garden

Our students have been informed about vertical gardening with the seminars given under the leadership of Assoc. Prof. Dr. Serdar Gökhan Şenol and, Duygu Bozyel from Ege University.In order to inform parents, teachers, other employees and all students of our school; purchased seedlings were placed on the felts used in vertical gardens in the school campus.The prepared model was exhibited hanging at themost suitable place and observed for weeks. A great interst and curiosity showed by primary, secondary and high school students were made us happy so much.

Figure 3. Vertical gardening practiced by secondary and high school students in Çakabey Schools garden.

2.2. Application studies at Çanakkale Bozalan Clay Quarry

On Monday, March 19, with the aim of studying the application area of our project better, we continued working together with our experts in Bozalan Clay Quarry. The locations where the saplings and the vertical gardens will be applied were determined. Areas close to the water pumps were selected, in particular for the irrigation to be easy and orderly. A team of carpenters, gardeners and technical personnel from Çakabey visited the Bozalan Mining Area to conduct preliminary research. Because the goats were still one of our biggest problems, we have estimated the amount of razor wire to be used to prevent this problem and where to put it. For our irrigation plan, we examined the water

sources in the area and selected the most suitable place for the temporary water reservoir to be used for drip irrigation.

In April, Izmir Cakabey Schools technical team went to Canakkale Bozalan Clay Quarry with the leadership of Assoc. Prof. Dr. Serdar Gökhan Şenol and Duygu Bozyel and successfully completed the field application of our project with the necessary equipments. A plastic water tank that has a volume of 1000 liters was bought and placed on the field in order to provide the watering for ensuring the adherence and germination of the seeds and seedlings and set up the drop irrigation system.In our club work, it was decided that two different types of horizontal and vertical plantation would be the best option in terms of field succession.Thus, the seeds were planted homogeneously between the two layers of felt.On the vertical surface, it was aimed to grow the seeds by fixing the seed-filled felt with iron bars. The plant seedlings used in vertical gardening (*Origanum onites, Salvia triloba, Capparis ovata*) were also fixed in pockets consisting of a double layer felt material. Details of the system are given below. In the horizontal garden, the surface was covered with fertile soil and the Turkish pines (*Pinus brutia*) and carobs (*Ceratonia siliqua*) were planted. The prepared area was surrounded by razor wire to protect against the goats.

It was designed 2 different plans for seed and seedling plantation:

For the seeds: Dissolvable material with 1,5 m of width and 5 m of length was divided vertically to be 15 cm wide. And then each was divided from the middle, creating 2 pieces. The prepared design was appropriately fixated on the wall. Next, the pockets we have created were filled with soil in a way that we had one pocket full, and one empty. With certain distances in between, we opened holes and planted seeds (the mixture of *Festuca sp.* and *Lolium sp.*) in them. Lastly, we established a drip irrigation system and ensure that each seed has comfortable access to water, using the natural resource in the quarry.

For the seedlings: Dissolvable material with 5m of length and width was divided into 15 cm squares. The prepared material was appropriately fixated on the wall. In the square pockets that we have created, seedlings(*Thymus zygioides, Echinacea purpurea, Melissa officinalis, Marrubium vulgare and Salvia triloba*) that were removed from their tubes were planted, again in a way that we had one pocket full and one empty. Afterward, we established a drip irrigation system and ensure that each seedling had comfortable access to water, using the natural resource in the quarry. Lastly, we surrounded this prepared area with a razor wire barrier to protect it from the grazing pressure, therefore establishing a safe environment for the seedlings to grow.

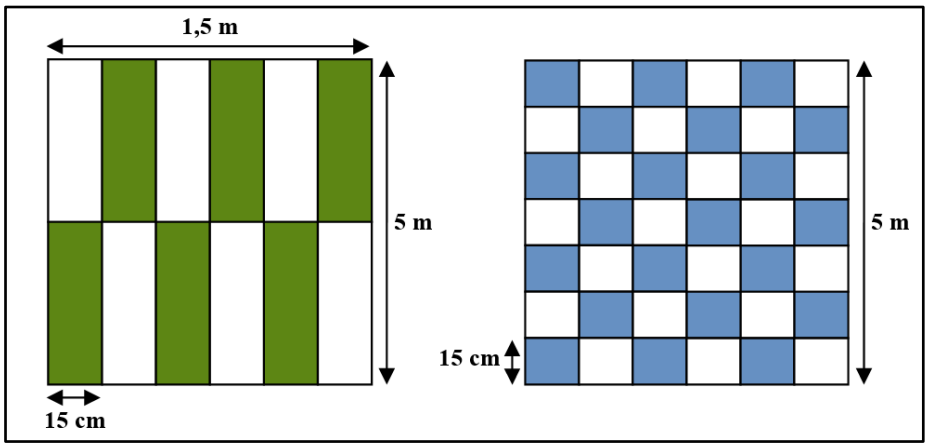

Figure 4. Plans of our designed system

On 19th of May our project students sustained their field trip in Bozalan Clay Quarry with our technical team and supervisors. They were thrilled to see that the planted pines and locusts adjusted to the environment and grew beautifully. In addition, they saw that the razor wire that was established to protect the system from the goats served its purpose.

They observed that the seedlings such as sages, thymes, and coneflowers were starting to bloom in the vertical gardening model and that the drip irrigation system had been successfully applied

in the upper part. But because of the clogging in the lower part, sufficient watering was not achieved and some of the seedlings were dry. They controlled the irrigation pipes and unclogged them.

Figure 5. Placement of the water tank in the application area and coating of the surface with fertile soil

Figure 6. The application of horizontal gardening performed by our secondary and high school students in Bozalan Clay field.

Figure 7. Students who controlled the water tank and irrigation system

They suggested to make small cuts on the felt with a snap blade knife to ensure that the germinated seeds could grow out of it, and completed the application successfully. Our students filled the big water tank that was placed for watering and watered the seedlings on the field while having a lot of fun.

2.3. Presentation for international jury and follw-up the application

In the morning of July 31st, we arrived in Çanakkale, Bozalan Clay Quarry in order to introduce our project to the international jury with the following students from our school Defne Sallı, Arda Derbent, Berke Korkmaz, Arda Çağan Karagöz, Doruk Sertkahya and our consultant teacher Viki Kalderon. We had lunch with the other participants and then headed to the meeting room. Our national

coordinator Caglar Geven lead the meeting as we presented our project in English to Prof. Dr. Ani Mardiastuti'ye(Lecturer, Faculty of Forestry, Bogor Agricultural University, Indonesia) and other participating teams.

Figure 8. Our team presenting to international jury. Introducing our project in Sasalı Primary School

2.4. Project promotion activities around the school

We introduced our project to kindergarten, 1st and 5th grade students through the seminars we held in Sasalı Primary School. This way, we reached different age groups in the area where our school is located. In the seminars, we aimed to draw attention to the harm that the clay quarries cause to the environment and biodiversity, and to explain the alternative solution we proposed. We have shown them that vertical gardening can be used as an easy, practical and low cost method. In addition, we shared our project firstly with the authorized people then with the visitors in İzmir Wild Life Park and received positive feedbacks.

3. RESULTS AND CONCLUSIONS

3.1. Success Ratio of horizontal and vertical gardening

The results of, horizontal and vertical gardening models and the studies in Bozalan Clay Quarry, which started in February 2018 and continued until August 2018, are given below.

Figure 9. Images from our horizontal gardening in Bozalan quarry

As seen in Figure 9, with the razor wire application used in the horizontal garden, seedlings survived against the animals. *Pinus brutia* and *Ceratonia siliqu*a that have been planted continued to grow and adapted to the environment.

Figure 10. Horizontal and vertical gardening samples in the clay quarry.

In vertical gardens we can easily see that growing plants is a very simple and efficient method. In our example, drip irrigation at the top of the application area took us to the desired result.The reason for not achieving the desired efficiency at the bottom is that the materials such as calcareous water in the construction site.Also, soil, dust and solid particles in the pipes can partially block the holes in the pipes. The solution we have produced to prevent the dehydration of the plants is to create an automatic irrigation system or an automatic irrigation system when the humidity sensor is connected to the Arduino Card and programmed to reduce the humidity.

In the field trip our students saw that adjust of planted pines and carobs in horizontal area to the environment and growing of them beautifully. In addition, they saw that the razor wire that was established to protect the system from the goats served its purpose. Asour seedlings kept on growing in Bozalan clay quarry, it was showed that both of our methods fit perfectly to the quarry. As it is seen in Table 4, the success rate for samplings planted in 40 m^2 of horizontal layer is 100% whereas the success rate of plants planted in half of the area of 30 m^2 the rate was 32%. On the other half of the area (15 m^2), 1 kg of seed was mixed with 10 kg of soil and approximetly 60% of germination and seed growth was observed. To summarize with vertical gardening samplings had 32% and seeds had 60% percent of success rate.

Table.2. Percent growth succsess of seedlings

Gardening Type	Species	Number of Seedlings Used	Number of Living Seedlings	Growth success by species
Vertical	Thymus zygioides	16	6	%37,5
	Echinacea purpurea	14	6	%42,85
	Melissa officinalis	19	5	%26,32
	Marrubium vulgare	9	2	%22,22
	Salvia triloba	7	2	%28,57
Horizontal	Pinus brutia	12	12	%100
	Ceratonia siliqua	6	6	%100

- ✓ The fact that our seeds and seedlings grew well and are still alive, confirms that our plan and its application was successful.
- ✓ It's believed that our method is an innovative way of ensuring plant diversity in rocky and inefficient areas.
- ✓ By demonstrating our vertical horticulture model in school yard, our students were informed about a sustainable environment and biodiversity.

- ✓ We are proud to show such social projects, new ideas reaching us from all over the world and to represent our country in the best possible way.

3.2. Cost of The System

Table.3.The number of seedlings used and their cost

Gardening Type	Species	Number of Seedlings Used	The Cost Per Plant (TL)	Cost (TL)
Vertical	Thymus zygioides	16	1,5	24
	Echinacea purpurea	14	1,25	17,5
	Melissa officinalis	19	0,50	9,5
	Marrubium vulgare	9	0,50	4,5
	Salvia triloba	7	1,5	10,5
Horizontal	Pinus brutia	12	2	24
	Ceratonia siliqua	6	2	12
TOTAL		**83**	**-**	**102 (15,5$ / 13,5€)**

Table.4.Cost of the applied model

MATERIAL	COST (TL)
Geotextile White Hose 2x15 m^2	27
Tailor's Fee	50
Drip Irrigation Hose 50m	25
Iron Bar	84
Wate Tank 1000 L	525
Razor Wire 60m	1578,84
Total Cost	2289,84

3.3. Presentation for international jury and follw-up the application

As Cakabey schools, all of our students' demonstrated a performance that was acclaimed by other participants. They experienced and made us experience the pride that comes with representing our country in the best way with their presentation skills, fluency in English and the way they had comprehensive knowledge on their subject. After the presentation, we went to the quarry to observe our field application. We observed that the application we made on the horizontal layers achieved 100% success and vertical gardening achieved 55% success. We have tried to eliminate the obstructions in the drip irrigation system. We explained all our work to the jury member. At the end of our highly acclaimed practice, we received important recommendations for the final report to be prepared.

3.4. Introducing Our Project to thePublic

Figure 11. Introducing our project to the public in Wildlife Park and Sasalı Primary School

4. SUGGESTIONS

Our students have started this project in the light of the information that they gained during the conferences and seminars given by the consultants from Ege University within the scope of this project in order to solve the current problem in mining fields. At the end of this project, our students would contribute not only to nature and ecosystem by improving the biodiversity in mining fields, but also to science. This project will increase the number of species in flora and fauna in the area. Thus, a healthy ecosystem would be provided in the area. In the end, a project can be supported and developed with the activities that are conducted by NGOs and social services. Besides, it is a great chance to show a new technique in terms of vertical gardening to farmers and locals theoretically and practically. It will arise awareness in our school after the project club students give seminar on their study.

4.1.Student Views

Defne Sallı (High school student): I believe that our project in the Canakkale Bozalan clay quarry is important for our world, especially for Turkey. As the area of usage for raw material increases along with technology and scientific breakthroughs, mining becomes more and more important, in this process however quarries are being derived of biodiversity. Ensuring the sustainability of biodiversity is our duty as we are the ones threatening it. For this reason I am extremely proud of our project and I am very hopeful towards its results.

Doruk Sertkahya (Middle school student): I was delighted to participate in this project because I care about the environment and I wanted to raise the environmental awareness of the public. In the field application, applying the vertical agriculture to such a difficult area, and finding a way to bring back the natural beauty of the Bozalan quarry area was a great feat for us. Fortunately, I am was involved in this project and proud of what we have done. I think, this will be a great example for the public and it will raise the awareness of the people.

Figure12. Cakabey school students who work in Bozalan clay quarry

The increase of new green areas in the region will not only bring back the dead area, it will also rebuild the fauna in the region while allowing the biodiversity to increase. We would like to thank everyone who has contributed to our project which is very fun, creative, efficient and fast.

ACKNOWLEDGEMENTS

We are thankful to our school for supporting us in every step of the project by providing transportation. We also sincerely thank Assoc. Prof. Dr. Serdar Gökhan Şenol, Duygu Bozyel for their valuable insights and experiences and all of the staff members who supervised the area.

5. REFERENCES

1. Bétard, F., 2013. Patch-Scale Relationships Between Geodiversity and Biodiversity in Hard Rock Quarries: Case Study from a Disused Quartzite Quarry in NW France, Geoheritage, Volume 5, Issue 2, p. 59–71
2. Van Gils, W., 2013. Ecosystem Services in Natuurpunt, Ecosystem Services, Pages 385-387
3. Okafor, F., C., 2006. Rural Development and the Environmental Degradation versus Protection Environmental Issues and Management in Nigerian Development, Environmental Issues and Management in Nigerian Development, p. 150-163
4. Ak, A., 2016. Açık Maden Ocaklarının Topraksız Zeminlerinde Bitkilendirme Uygulamaları, Yüksel lisans tezi, Ege Üniversitesi Çevre Bilimleri, p. 101
5. https://www.quarrylifeaward.com/quarries/turkey/bozalan-clay-quarry
6. Akten,S., Akten, M., Gül,A., Keleş,E., 2014.Jeotekstillerin Peyzaj Onarımında Kullanım Olanakları. Ulusal Mermer Ve Taş Ocakları Onarım Teknikleri Sempozyumu, Isparta
7. https://www.britannica.com/science/maquis-vegetation
8. https://www.popularmechanics.com/home/how-to-plans/how-to/g847/how-to-start-a-vertical-garden/
9. Jain, R., Janakiram, T., 2016. Vertical Gardening: A New Concept of Modern Era, Commercial Horticulture, pp 527-536. Editors, N.L. Patel, S.L. Chawla and T.R. Ahlawat New India Publishing Agency, New Delhi, India
10. http://dergipark.gov.tr/download/article-file/92476
11. Yıldız, L., 2005. Donatıyla Güçlendirilmiş Şevli Zemine Oturan Yüzeysel Temel Analizi. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, İnşaat Mühendisliği AnabilimDalı Yüksek Lisans Tezi, Adana
12. Toğrol, E., Güler, E., Merdin, E., 2004. Teknolojik Gelişmeler (II). Türkiye İnşaat Mühendisliği 8. Teknik Kongresi, İstanbul
13. http://megep.meb.gov.tr/mte_program_modul/moduller/Dikey%20Bah%C3%A7eler.pdf
14. http://cdn.intechopen.com/pdfs/45441/InTech-Vertical_gardens.pdf
15. www.geoplas.com.tr/turkce1/geotekstil.html (Last accessed: 06.09.2018 16.27)