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Design Proposal Model for Improving Rivers with Phytoremediation Method

Merve TOKMAK, Deniz BERTİZ, Deniz ÖZBEY, Ilgaz EKŞİ, Mehmetali AK, Aslı GÜNEŞ
1Izmir University of Democracy, Faculty of Architecture, Department of Landscape Architecture, İzmir
*Corresponding Author: tokmakmerve@outlook.com.tr
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ABSTRACT

Discharge of heavy metal-containing wastewater caused by industrialization and urbanization has led to significant deterioration in aquatic ecosystems. In recent years, the restoration of ecological balance by natural methods; facilitated adaptation, reduced costs and at the same time increased sustainability. It is known that phytoremediation method is used frequently in artificial wetlands and it has been designed by using phytoremediation method which is a natural treatment system for the treatment of streams with water surface.
Keywords: Phytoremediation, Wastewater, Streams, Design Model

INTRODUCTION

Since people began to live in communities on earth, they have begun to contaminate, change and disrupt their environment. For this reason, the problem of environmental pollution that threatens all humanity today is as it is thought to be 20. century, it is a phenomenon that begins when the first cities are established and the waste is emptied into the water. In short, the pollution event has begun, with the human being affecting the ecological balance[9].Nowadays, waste water discharge to rivers on large scale of industries appears to be a serious danger in contamination of river waters[7,2]. Rapid growth of urban areas and industrial development result in the formation of wastewater requiring advanced treatment before discharge. Waste water discharged without any treatment process; Polluting streams, rivers, lakes and seas, and even mingled into groundwater through leakage, causing pollution to reach dimensions that threaten the environment and human health[17,19].

Water pollution is increasing day by day and poses a threat to living things. For a healthier and more quality life, a solution to water pollution should be sought.

Today, increasing water demand requires good utilization of water resources, and therefore alternative methods for the recovery and use of existing water resources are investigated[19].As the water is an increasingly declining and therefore valuable resource, the absence of a holistic and systematic strategy on the planning of water basecoats and the fact that it exhibits a structure that is immediately affected by the ecological changes in the global scale is increasing in importance[1,19].Water pollution, which is a variant of environmental pollution; In recent years, the proliferation of industrialization, the issuance of domestic and industrial wastewater in the receiving environment, is increasing significantly due to the unconscious fertilization and pesticides used[17,19]. Among the different pollutants, heavy metal pollutants are the main environmental problem that the modern world should face. Heavy metal accumulation and neutralization in Sedimentte has been a focal point in scientific research in recent years[8,2]. The understanding that water resources need to be maintained and transferred to future generations has increased efforts to ensure the efficient collection and disposal of wastewater, even in very small settlements today[19].

Heavy metals are involved in wastewater, damaging nature and living creatures. In particular, it threatens the living life in the water and it damages the human life as it is thought to be chained. The environmentally friendly and economical treatment of wastewater is important for living beings.

Wastewater treatment can be carried out using natural or conventional steel concrete treatment technologies, and each technology has its own advantages and disadvantages[15,19].The main components of wetlands are filler material and water. The most important factor in the work of the system is the capacity of purification of plants. Plants that transmit oxygen from the air through their roots to wastewater, also provide the purification of water using pollutants (nitrogen, phosphorus, etc.) found in wastewater through its roots. Wetland plants also have the ability to suspend hazardous substances from agricultural medicines or mining enterprises. The types of water hyaclium (*Eichhornia crasspies*) and some *Typha* and *Phragmites* can be removed from water by collecting heavy metals such as cadmium, zinc, mercury, nickel, copper and vanadium in their tissues[19].Wetlands plants have important roles in wastewater treatment. Firstly, the plants provide acceleration of the sedimentation event by reducing the flow rate and re-suspension of water in the wetlands bed[12,19].

Although phytoremediation studies are mainly used for cleaning contaminated soil and water environments, nowadays it has become more widely used in water treatment in order to support the increasing water demand from treated wastewater. Especially in rural areas, artificial wetland systems, which are used in less populated settlements, are among the main uses for phytoremediation[10].
Since natural treatment methods are environmentally friendly in wastewater treatment, it is advantageous for the main material to be a plant. The aim of this article is to explain the phytoremediation method, which is frequently used in artificial wetlands and which is thought to be suitable in rivers, to explain the advantages and disadvantages of this approach, to reveal economic, aesthetic and functional design compatible with nature for use in landscape design.

Phytoremediation

Phytoremediation, which is from natural wastewater treatment systems, is derived from the words “Phyto” in plant meaning and “remediation” in reclamation meaning. Is a term used for the first time in 1991 and is the technology of breeding the environment using plants. In various sources he is referred to by different names such as “Phytoremediation”, “botanical remediation” or ”green remediation” [20,13].In some sources, the word “herbal treatment” is suggested in Turkish [21,13].

Phytoremediation is the removal of pollutants such as heavy metal in soil or water from the environment using plants or algae, or the removal of their toxic effects[24,13]. Phytoremediation is an ecology-friendly technology that envisions the effective use of plants in the cleaning and repair of water and soil pollution. Heavy metal pollution has recently become a global threat, and phytoremediation technologies in plant-based cleaning of contaminated soil and water are becoming increasingly important[6].Phytoremediation of wetlands in a laboratory setting has a rich trial history. Different behaviors of plants in changing environmental conditions make it difficult to assess the potential for phytoremediation. So full-scale field applications are constrained by the number of several suggestion - mechanisms. There is little research on the accumulation of metal pollutants in aquatic ecosystems, sediments, and aquatic plants in the natural environment[8,2].
Research has shown that plants that survive in contaminated natural environments are the token of high heavy metal concentrations in aquatic systems[25,2]. This has shed light on the fact that plants can be used in the improvement of natural environments and aquatic systems by the phytoremediation technique[2]. It has been shown that phytoremediation techniques can remove Zn, Ni, Cu, Hg, Cd and many other heavy metals, Sr, Cs, and U, radioactive elements, various pesticides and herbicides, petroleum hydrocarbons and industrial organic wastes[24,13]. Compared to chemical and physical removal techniques, the phytoremediation method is more preferred as a method of removal which is considered financially low-cost, has no destructive and negative effects on the environment, is environmentally friendly and efficient because it uses solar energy[14,13].
Advantages and disadvantages of phytoremediation method have been demonstrated. These items are shown below [23,2].

Advantages;

- ✓ Economical and low cost.
- ✓ Does not destroy the natural environment.
- ✓ The risk of spreading contaminants during disposal is low.
- ✓ It is more aesthetic than traditional methods.

- ✓ It has the potential to improve contaminated environments with more than one type of pollutant.
- ✓ It can be used against large scale pollution factor.
- ✓ Toxic conditions can be easily monitored in plants.
- ✓ Phytoremediation is a method that protects the environment at least because it uses all natural organisms in the reclamation process.

Disadvantages;

- ✓ Plant growth conditions (climate, geology, temperature and s.) depends on.
- ✓ Contaminant removal depends on the tolerance of the plant.
- ✓ Large-scale applications require access to agricultural equipment and information.
- ✓ It depends on the growth rate of the plant compared to other technologies and the recovery time is long.
- ✓ It is only suitable for the treatment of low or medium contaminated. environments..
- ✓ Improvement by phytoremediation is limited by the surface area and the root area accessible to plants.
- ✓ Evaluation of plant wastes after removal with plants can create problems.

Phytoremediation Plant Selection

Plant selection is quite important in phytoremediation. In order to determine the metal uptake efficiency of the plant in phytoremediation, detailed investigation of the species development, planting density, growth rate, optimal planting conditions and time, Disease Control and harvesting methods should be undertaken. In addition, the performance value of the application, the use of end products and by-products, and the overall economic infrastructure are issues that need to be taken into account[2].

There are some important criteria to consider when selecting plants for use in phytoremediation[16,2].

- ✓ Tolerance level of known metals in the environment where it is planted
- ✓ Sufficient accumulation, transport and disposal of metals
- ✓ High growth rate and biomass efficiency
- ✓ Durability to flood and extreme drought conditions
- ✓ Habitat preference For example, terrestrial, aquatic, semi-aquatic environments
- ✓ Tolerance to high pH and saltibility
- ✓ Root characteristic and depth of root region

Most of the rivers are supplied with wastewater from industry, industry and urbanization. The choice of plants to be grown in polluted waters is very important and the tolerance of each plant to the environment is different. In his thesis work in Kaybal [11], he touched on the plants that continued their lives in dirty environments. These plants are divided into three groups as tolerances, indicators and hyperaccumers according to their relationship with the environment.

These are;
Tolerant species: they do not allow pollutants to enter their roots in environments polluted by certain elements that will harm many plants and survive in that environment [3, 18,11]. In this respect, both the indicator and hyperaccumulative species are tolerant. Studies have shown that the related mechanisms of plants differ genetically. Tolerance species *Holcus lanatus, Agrostis capillaris*, *Mimulus gultatus* and *Silene vulgaris* can be given as examples [5,11].
Indicator plants: plants in this group have poor control over metal uptake and conduction processes in their environment. Since the degree of metal deposition in these plants indicates the concentration of metal in the soil rhizosphere, such plants are used in the exploration of new mineral ores in mining. For example, blackwater known as biological indicators of high metal concentrations in water and *Stanleya pinnata* known as Se indicator [5,3,18,11].

Hyperaccumulative plants: plants in this group they do not prevent pollutants from entering their roots, but they allow high concentrations of pollutants to bioaccumulate, as they have developed specific

mechanisms to remove the toxic effect of pollutants in their metabolism. The defined levels of elements in the hyperaccumulators are much higher than those detected in non-accumulator species.
Hyperaccumulative species were detected from 45 different plant families, the highest metal accumulation was in *Brassicaceae* family. These plants vary from annual small grasses to long-lasting shrubs and trees[5,11].

MATERIAL AND METHOD

The material of the study was composed of various visual and literary materials such as domestic and foreign literature, internet-based publications, figures and photographs. In order to reach the previous studies and literature, resources obtained from internet and various symposium activities were used. At the same time, an original design and modeling for the problem was made using Autocad 2014 and Adobe Photoshop CS6.

Within the scope of the study, in order to find solutions for river pollution in the city, the main sources of pollutants, their effects on soil, water and living beings, physical - chemical and biological treatment methods developed for rivers and alternative phytoremediation method were used.

FINDINGS

Rivers are named according to their size and volume in terms of brook, stream, river and river(Figure-1). The rivers have different widths from the source part to the sea. In this case, a portable, economical, energy-free design model that would not require maintenance and repair was needed.

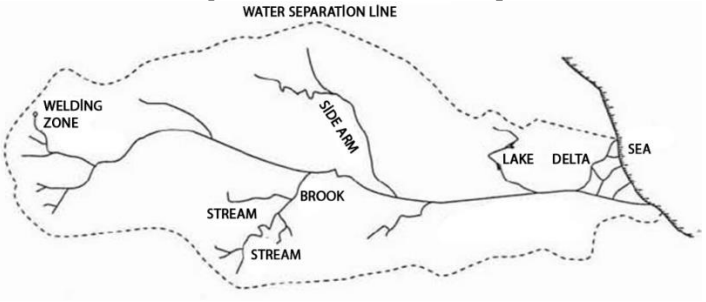

Figure-1

The design model to which phytoremediation method will be applied was inspired by the shape of the letter “L”. In this design example, design dimensions are shown in Figure-2 below. According to the structure of the river, these dimensions can be changed.

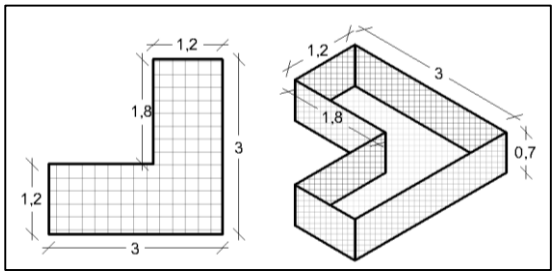

Figure-2

The form of "L" allows it to create various design combinations as a result of effects such as wastewater discharge direction in streams, areas where pollution is dense, etc. A single system can be used in different ways within the stream or it can be used in a community (Figure-3).

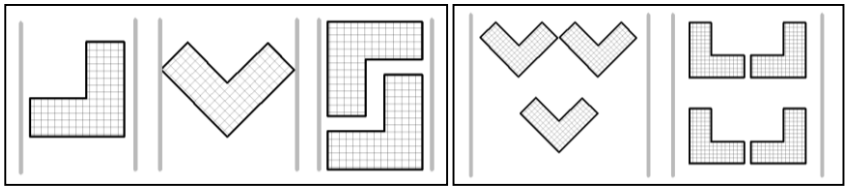

Figure-3

The material layers that make up the model are shown in Figure-4. The main frame consists of a wire cage (1). The inside of the wire frame is filled with a layer of the creak (2) and a soil layer (3) respectively. It is then covered again with wire (4). The wire frame size used in the main frame is 5x5 and the wire to be covered on top is 15x15 dimensions.

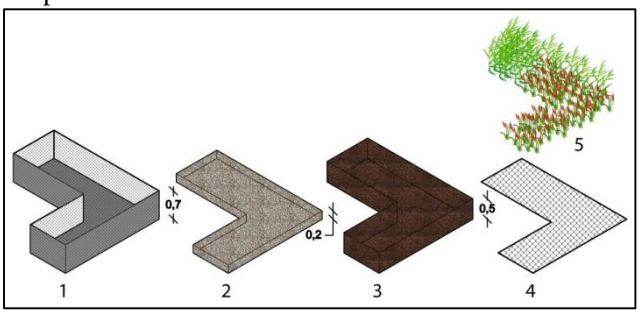

Figure-4

The stone chips layer will both make weight and reduce the surface flow of water from the stream. Soil layer is important for the development of the plant. In the soil layer where the roots are located, there will be water accumulation and the plants planted on it will draw heavy metals from the water and give oxygen instead. The selection of wetland plants (5) varies according to the problem and need of the environment. Finally, the system appears to be in Figure -5.

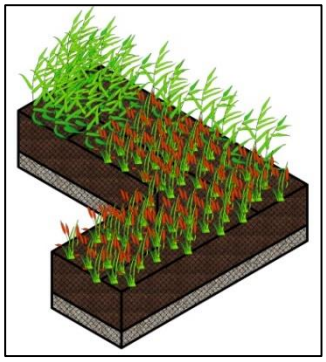

Figure-5

In order to make the design model understandable, streams with different widths and dirty water were modeled (Figure-6). Here it can be shown as an answer to the question of how the design model in which phytoremediation method will be applied will look in rivers.

Figure-6

The view of the formation layers of the "L" shaped design model in the stream is shown in Figure-7.

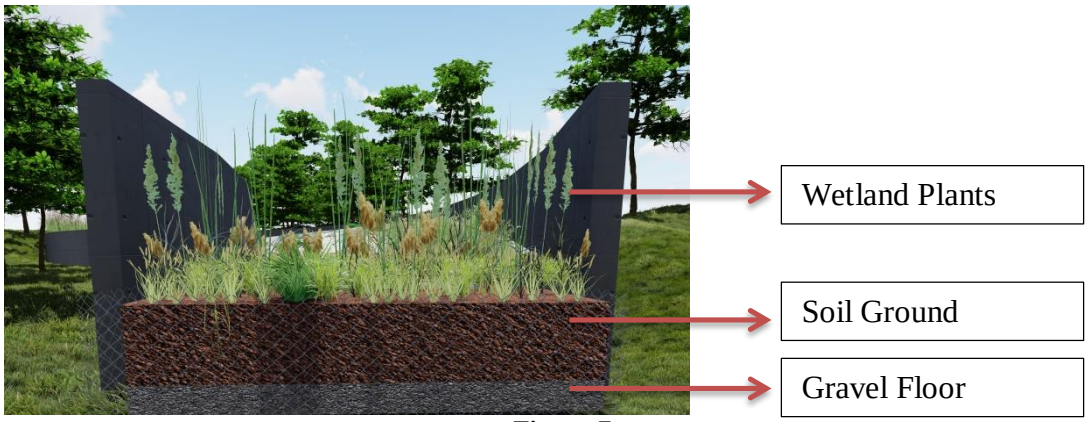

Figure-7

The combinations of the "L" design model in the field are shown in Figure-8 below.

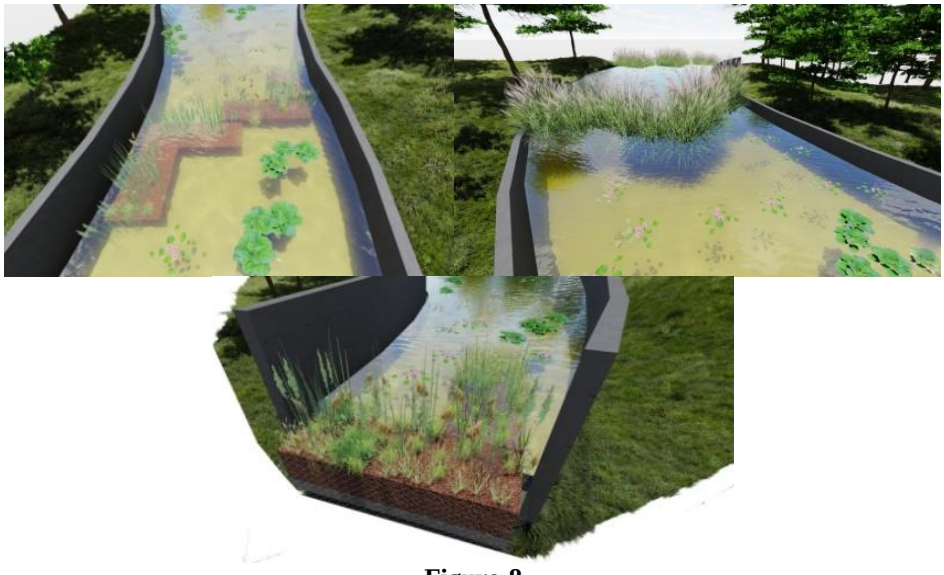

Figure-8

Besides the design model system, swimmer wetland plants can also be used (Figure-9).

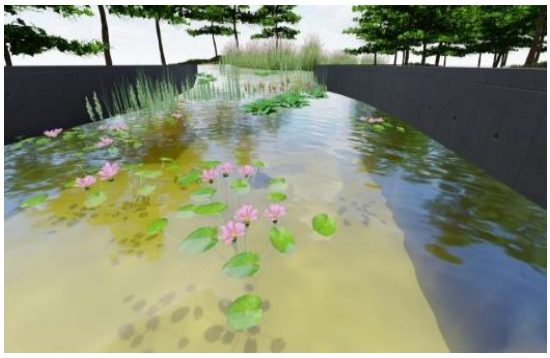

Figure-9

CONCLUSION

Over time, the air, water pollution and noise created by the industry have forced them to move out of the city again. After the industry is moved out of town, abandoned industrial zones and polluted streams and soil remain in the middle of the city. These areas are located in the middle of the city as physical barriers isolated from the urban fabric that hinder economic development and use of urban areas. The delicate, aesthetic quality that goes through this ruined area is rediscovered with designs implemented in landscape architecture [4,11].

Rivers are green infrastructure systems that connect rural and urban areas and also act as corridors. The streams, which constitute an important part of the ecological cycle, are polluted as a result of various uses. New methods are being developed for the cleaning of rivers whose importance cannot be denied. Phytoremediation is one of the environmentally friendly methods.

The principle of performing the materials and procedures to improve contaminated zones to ensure the preservation and sustainability of the natural balance increases the acceptable ability of methods. Fitoremediation Technology aims to improve the plant with the aim of improving the balance of nature, the high feasibility, the water, sediment and soils to smash, stabilize and remove contaminants. For the success of this technique, the intensity of pollution, tolerance of pollution and the selection of the Accumer plant, preparation and follow-up of the appropriate environment for the development of the plant and the planning of the period of improvement will be considered. Protecting pollutants, improving contaminated environments is essential for the sustainability of the ecosystem. The fitoremediation that performs all of these cases is an improvement technology to be investigated, developed and transferred to the application [22].

As a result, phytoremediation method, which is an ecological and economic treatment system, ensures that pollutants are removed from the environment without disturbing the river regime. Obtaining the desired efficiency from this method, healthy operation of the river systems and the ability to maintain its functions in every season depends on the right plant selection, correct design and error-free application. Plant species growing in the system, the most valuable natural resource while recycling water, other resources and environment does not harm, consumeless energy even supporting alternative methods will increase the chances of implementation, landscape ecology will help to implement sustainable practices in size.

REFERENCES

[1] Akten M., Akten S., 2008. Kentsel Atıksu Yönetimi Ve Atıksuların Yeniden Kazanımında Yapay Sulak Alanların Çevresel Sürdürebilirlik Üzerindeki Etkileri, Tmmob 2. *Su Politikaları Kongresi*, Ankara, 20-22 Mart.

[2] Aliyeva, Günel (2014).” Fitoremediasyon Yöntemi (Bitki) İle Sucul Sistemlerin İyileştirilmesi”, Yıldız Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul

[3] Anonymous. 2012a Web Sitesi:Http://Www.Agri.Ankara.Edu.Tr/Soil_Sciences/1250__Ayten_Cts_Dersnotu. Erişim Tarihi: 18.9.2013

[4] Anonymous. 2010. Web Sitesi: Http://Scholarworks.Umass.Edu/Cgi/Viewcontent.Cgi?Article=1143&Context=Soilsp Roceedi Erişim Tarihi: 15.01.2014

[5] Arlı, S. 2006. Arıtma Çamurlarındaki Ağır Metallerin Bitkilerle Giderimi, Yüksek Lisan Tezi(Basılmamış). Sakarya Üniversitesi, 20-25s., Sakarya.
[6] Bahtiyarca Bağdat, R., Akan, K., 2008. Bozulmuş Ekolojik Dengenin Bitkilerle Onarılması (Fitoremediasyon) Ve Tıbbi Ve Aromatik Bitkilerin Bu Onarım Sürecindeki Rolleri. Ziraat Mühendisliği Dergisi. Ocak-Haziran 2008 Sayı:350.S.56(34-37).
[7] Bonanno, G. Ve Giudice, R. L. O., (2010). "Heavy Metal Bioaccumulation By The Organs Of *Phragmites Australis* (Common Reed) And Their Potential Use As Contamination Indicators". Ecological Indicators, 10: 639–645.
[8] Chabukdhara, M. Ve Nema, A., (2012). "Heavy Metals İn Water, Sediments, And Aquatic Macrophytes: River Hindon, India." Journal Of Hazardous, Toxic, And Radioactive Waste, 16(3): 273–281.
[9] Doğan Muhittin , "Akuatik Makrofitlerde Ağır Metal Akümülasyonu", Türk Bilimsel Derlemeler Dergisi 4 (2):33-36, 2011, Gaziantep Üniversitesi, Fen-Edebiyat Fakültesi, Biyoloji Bölümü, 27310, Gazıantep
[10] Güneş, Aslı(2018)," Yapay Sulak Alanlar, Atık Su Arıtımı Ve Sucul Bitkiler",Plant Peyzaj Ve Süs Bitkiciliği Dergisi, Http://Www.Plantdergisi.Com/Doc-Dr-Asli-Gunes/Yapay-Sulak-Alanlar-Atik-Su-Aritimi-Ve-Sucul-Bitkiler.Html
[11] Kaybal, Gülşen(2014)," Ağır Metallerle Kirlenmiş Toprakların Fitoremediasyonunun Peyzaj Mimarlığı Açısından Değerlendirilmesi", Ankara Üniversitesi, Fen Bilimleri Enstitüsü, Ankara
[12] Merz, K., 2000. Guidelines For Using Free Water Surface Constructed Wetlands To Treat Municipal Sewage,
[13] Nassouhi, Danial, Et Al. "Ağır Metal Kirliliğinin Biyoremediasyonunda Bazı Su İçi Ve Yüzücü Sucul Makrofitlerin Kullanımı." Yayın Kurulu/Edıtorıal Board: 148.
[14] Razzaq, R. (2017). Phytoremediation: An Environmental Friendly Technique - A Review. Journal Of Environmental Analytical Chemistry, 4(2), 195
[15] Saeed T., Sun G., 2012. A Review On Nitrogen And Organics Removal Mechanisms İn Subsurface Flowconstructed Wetlands: Dependency On Environmental Parameters, Operating Conditions And Supporting Media, *Journal Of Environmental Management*, 112, 429-448.
[16] Sarma, H., (2011). "Metal Hyperaccumulation İn Plants: A Review Focusing On Phytoremediation Technology". Journal Of Environmental Science And Technology, 4(2): 118-138.
[17] Sayadi M. H., Kargar R., Doosti M. R., Salehi H., 2012. Hybrid Constructed Wetlands For Wastewater Treatment: A Worldwide Review, *Proceedings Of The International Academy Of Ecology And Environmental Sciences*, 2(4), 204-222.
[18] Özay, C. Ve Mammadov, R. 2013. Ağır Metaller Ve Süs Bitkilerinin Fitoremediasyonda Kullanılabilirliği, Baü Fen Bil. Enst. Dergisi Cilt 15(1) 67-76 S. Denizli
[19] Özyer, Ayşe (2014)." Fitoremediasyonla Kontrollü Şartlarda Bazı Ağır Metallerin Giderimi Ve Kinetiğinin Araştırılması ",Ondokuz Mayıs Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi, Samsun
[20] Us Epa. (Environmental Protection Agency), "Introduction To Phytoremediation", Epa/600/R–99/107, Cincinati, Ohio, U.S.A, Pp: 72, Http://Www.Clu-İn.Org
[21] Yalçın, V. (2014). Bazı Ağır Metallerin (Pb, Cd, Ni) Sucul Bitkiler (Salvinia Natans (L.), Lemna Minor L.) Üzerinde Yaptığı Stres Ve Biyolojik Yanıtlar, Nevşehir Hacı Bektaş Veli Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Nevşehir.
[22] Yurdakul, İlknur (2015)," Kirletilmiş Topraklarda Ve Sularda Bitkisel İyileştirme Teknikleri Ve Önemi", Toprak Gübre Ve Su Kaynakları Merkez Araştırma Enstitüsü Müdürlüğü, Ankara, Türkiye
[23] Vangronsveld, J., Herzig, R., Weyens, N., Boulet, J., Adriensen, K., Ruttens, A., Thewys, T., Vassilev, A., Meers, E., Nehnevajova, E., Lelie, D. Ve Mench, M., (2009). " Phytoremediation Of Contaminated Soils And Groundwater: Lessons From The Field", Environmental Science And Pollution Research, 16 (7): 765-94
[24] Vasavi, A., Usha, R. & Swamy, P. M. (2010). Phytoremediation – An Overview Review. Journal Of Industrial Pollution Control, 26(1), 83-88.
[25] Vicente-Martorell, J. J., Galindo-Riano, M. D., Garcia-Vargas, M. Ve Granado-Castro, M. D., (2009). "Bioavailability Of Heavy Metals Monitoring Water, Sediments And Fish Species From A Polluted Estuary", Journal Of Hazardous Material, 162: 823-836.