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RESEARCH FOR OPTIMIZATION OF GREEN SPACES DESIGN AND IRRIGATION IN BUCHAREST'S PLAIN

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Abstract

Turf and ornamental plants are considered an integral part of worldwide ecological landscape. Since antiquity, they are used by people to enhance the form and value of their environment. In these meaning green spaces industry and its irrigation must prove the ability to manage the efficiently and effectively administration of water to the plants. Irrigation water management depends on the soil and climatic conditions, landscape plants type and type of irrigation system. The purpose of the research, namely the development of green areas with irrigation systems in Dobroieşti park in Bucharest, have been the depth study and analysis of soil parameters, climatic conditions (rainfall) and water consumption (ETRO) of outdoor ornamental plants in Bucharest Plain. These results were correlated to the topography of the site in order to develop a technical project for landscape construction, to set the elements of the irrigation regime and to determine the optimal plants watering program. The results have been materialized, in establishing by water balance in soil method, the values of the irrigation norm for lawn, floral elements, trees and shrubs, the optimal timing for application of irrigation, the design of the technical elements of irrigation system and its running parameters for a sustainable exploitation.

Key words: *design, evapotranspiration, irrigation, green spaces, sprinkler.*

INTRODUCTION

The development of green spaces constitutes a major and indispensable chapter in the evolution of urban and rural development, both globally and nationally for Romania, being treated as a long-term national strategy for improving the environmental quality in populated areas [1, 2, 3].
In the last years' Romania, by adopting and implementing the European strategies on the Community environmental policies, the national efforts were intensified both administratively and economically and socially regarding the programming, design and green spaces development activities in cities, both as new sites and rehabilitation and expansion of the existing ones [4].

The purpose of the research study was the landscaping development with irrigation systems of a land located in the 2nd District, Bucharest, in the public domain, alongside the Dobroiesti Lake in Pantelimon neighbourhood, with an area of 21,900 square meters. The land is characterized by a marked level difference from south to north, towards the lake plane, of about 10 m, according to the surveying study. The maximum altitude is about 74 m and the minimum about 64 m.
In terms of this research study, we were concerned that of the portion allocated to the global freshwater consumption of the capital, a part thereof, related to the water for domestic use (drinkable and household water) and the industrial water, must be responsibly used for irrigating the green spaces [5].

According to the studies made by John H. Lowry Jr. et al. in 2011, the estimates of water consumption vary greatly depending on climate, evapotranspiration, soil conditions, economic and social specificities of the region. In this regard the irrigation system must be designed and operated in optimal hydrodynamic parameters and to provide the necessary irrigation water needed for the plant development [6].

MATERIAL AND METHOD

During the research study, many working methods have been applied, such as: consulting the specialized references, maps, geographical and surveying studies, evaluating the initial site condition, field measurements, hydrodynamic calculation and two-dimensional technical design, to achieve the proposed objectives by the chosen theme. Thus, specific methods have been applied depending on the objectives pursued for:

- researching the landscape;
- establishing the irrigation elements for designing the landscape planning solution and the irrigation system [7];
- specifying and analyzing the technical landscape development solutions and determining the technical watering elements required in the design and operation of the green spaces in the studied site [8].

To calculate the irrigation and development, *"The Soil Water Balance Method"* has been applied [9]. The method has been established for the growing season of component ecosystems, i.e. April 1 to September 30 for lawn, trees and shrubs and April 15 to September 30 for herbaceous flowers.

Thus, according to the method presented by Jinga et al. in 2009, using the hydrologic balance equations for the growing season, the monthly and annual irrigation water demand has been determined by the following general formula [10]:

$$\text{“}\sum_m = ETRO - P_v - A_f - (R_i - R_f) \quad (m^3/ha)$$

where:

- $\sum m$ - is the annual demand (irrigation rate) of irrigation water in m^3/ha;
- ETRO - optimal real evapo-transpiration or total water consumption during the growing season through the plant transpiration and evaporation at the soil surface of an ecosystem, cultivated in a soil moisture which ensures the viability and normal development of plants, in m^3/ha;
- P_v - useful amount of rainfall during the growing season to ensure 80%, in m^3/ha;
- A_f - water input of underground water, in case of the closed circuit balance (Rota de Jos), in m^3/ha;
- R_i - soil water reserve at the beginning of the growing season, in m^3/ha;
- R_f - soil water reserve at the end of the growing season, in m^3/ha."

RESULTS AND DISCUSSIONS

In the context of the site integration in the reference pedoclimatic area, the natural framework of the area, where they conducted researches, has been researched. The data have been reported to relief, topoclimate, geological and pedological structure of soil, hydrology, hydrogeology and social and economic structure of the area.

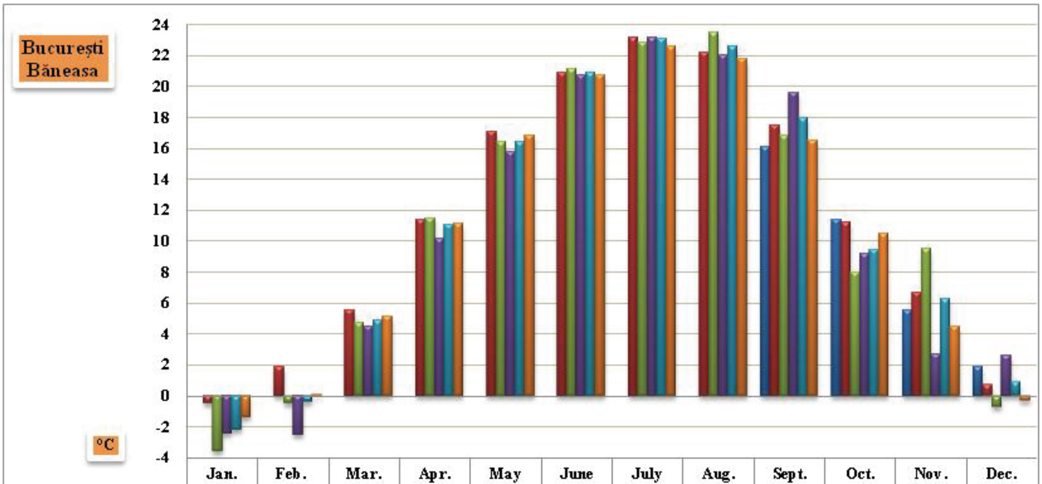
Thus, the relief in Bucharest Plain presents in its majority as a river-lake plain, covered with loesoid deposits with a tabular or undivided form and divagation and Holocene plain looking as a major bed. The form of piedmont-terminal plain, strongly provided with earthworks and many tablelands bordered by terse face and field is predominant in the city of Bucharest. It is slit at north by Colentina Lake meadow and in centre by the Dambovita meadow [11].

From the climatic point of view, Bucharest Plain integrates in the specific nature of Vlasia Plain, similar to the topoclimate in Titu-

Potlogi divagation Plain, Titu-Sarata Plain respectively.

In the Romanian Plain its central position is definitely reflected by a transition character of the climatic particularities from the attenuated oceanic and sub-Mediterranean particularities with moderate nature to the eastern ones which are excessively continental and with character of aridity. On the other hand, Bucharest central presence in the plain provides an anthropical climatic protection. Also the metropolis changes the climatic parameters form, giving them a concentric and circular form of Bucharest [12, 13].

In the past 30 years, namely during 1980-2011, the average annual air temperature in Bucharest Plain and the city of Bucharest strengthened around 10.7^{o}C. The monthly values of average air temperature measured at the Bucharest-Baneasa meteorological station, between September 1, 2008 - December 31, 2011 and the multi-annual values during 1980 - 2010 are presented in Figure 1.



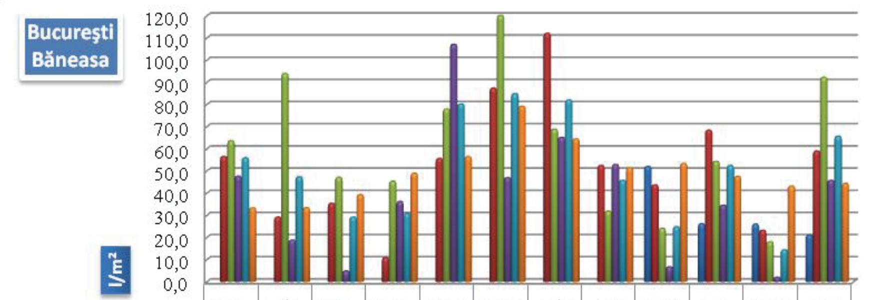
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2008									16,1	11,4	5,5	1,9
2009	-0,5	1,9	5,5	11,4	17,1	20,9	23,2	22,2	17,5	11,2	6,7	0,7
2010	-3,6	-0,5	4,7	11,5	16,4	21,1	22,8	23,5	16,8	8,0	9,5	-0,7
2011	-2,4	-2,5	4,5	10,2	15,8	20,7	23,2	22,0	19,6	9,2	2,7	2,6
Average 2009-2011	-2,2	-0,4	4,9	11,0	16,4	20,9	23,1	22,6	18,0	9,5	6,3	0,9
Average 1980-2010	-1,4	0,1	5,1	11,1	16,8	20,7	22,6	21,8	16,5	10,5	4,5	-0,3

Fig. 1. Evolution of average air temperature (^{0}C) in Bucharest Plain.
Monthly average measured at the meteorological station Bucharest-Băneasa

The annual average rainfall in Bucharest Plain, measured by the Bucharest-Baneasa meteorological station during the reference period 1980-2010, had values of 593.6 l/m^2. The average monthly rainfall values measured by Bucharest-Baneasa meteorological station between September 1, 2008 and December 31, 2011 and the multi-annual values during 1980-2010 are presented in Figure 2.

From the pedological point of view, the reddish brown soil streaked by two large alluvial soil strips along the Dambovita and Colentina Rivers' meadows in the downstream of Dobroiesti is specific to the Bucharest Plain. In the meadow of the chain of lakes of Colentina River in the upstream of Dobroiesti, brown alluvial soils have been abundantly identified [14].

In the west side of the city, in Ciorogarla and Chitila localities and in the east side, in Cernica, reddish brown podzolic soils have been identified. In the north-eastern side of the capital city, in Afumati-Sindrilita area, chernozem-type soils (levigated chernozem), and in the north side of the city, strong levigated chernozems strongly alternating with reddish brown and reddish brown podzolic soils have been identified in islands.



	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2008									51,9	26,1	25,9	21
2009	56,4	29,1	35,3	10,8	55,5	87,3	112,0	52,3	43,6	68,3	23,1	58,9
2010	63,5	93,8	47,0	45,2	77,8	120,0	68,7	31,7	24,0	54,2	17,9	92,1
2011	47,5	18,7	4,8	36,1	107,0	46,9	65,0	52,8	6,6	34,4	1,9	45,6
Average 2009-2011	55,8	47,2	29,0	30,7	80,1	84,7	81,9	45,6	24,7	52,3	14,3	65,5
Average 1980-2010	33,2	33,3	39,2	48,8	56,4	79,1	64,3	51,3	53,3	47,4	43,0	44,3

Fig. 2. Monthly rainfall (l/m^2) in Bucharest Plain.
Monthly average, measured at the meteorological station Bucharest-Băneasa

The hydrographic network of Bucharest Plain is relatively dense and with significant volumes compared with its relatively small area.
The Bucharest Plain is situated in the Arges River drainage area, at its north side. The north side is bounded by Pasarea temporary watercourse, whose meadow is closed in the east side, in the confluence area with the Dambovita River.
The analyzed internal network from north to south is dominated by the permanent rivers: Colentina, Dambovita, and Ciorogarla. They evolve on the north-west south-east direction and are complemented by the temporary watercourse – Sindrilita in the northeast side, from Cocioc and Sabar (Rastoaca) in south and Calnau in east. A series of 15 semi-natural lakes in the form of chain resulted from the works for regulating the water flow of Colentina River that occurred during 1933-1939 is specific to Bucharest. They spread along a surface of 54 km with a level difference of 49 m, a total area of 1,500 ha and a volume of 44 million m^3. These also include Dobroiesti Lake. The area is closed by Cernica Lake, being the largest in size between them..
The hydrological regime of the main over-ground watercourses which frame and cross the Bucharest Plain is described in Table 1.
Along the entire area of Bucharest Plain, three underground bodies of water have been identified: body of underground water ROAG03-Colentina and bodies of groundwater ROAG11 Bucharest-Slobozia and ROAG13 – Bucharest [15].
The social, economic and demographic elements in Bucharest Plain are strongly influenced by the presence of the metropolis in that area, being characterized by a large number of inhabitants, over 5.000, there being cases where they exceed 20,000 inhabitants (Voluntari, Buftea, Mogosoaia, Jilava, Magurele, Cornetu etc.). The main activities of the inhabitants of Bucharest Plain are industry, services and agriculture.
According to the Bucharest City Hall web site, it states that as a result of the 2008 census, Bucharest had a total of 1,943,981 inhabitants (just over 9% of the country’s population) of which 51% is the active population. Of these, 18.5% work in industry, 18.6% in commerce, 12.3% in construction, 3.4% are civil servants, 5.5% work in education, 5.3% in health, 3.9% in finance, banking and insurance, 14.2% work

in real estate, rental and services for enterprises and 18.3% in other areas [16].
The density of population in Bucharest alternates by area and administrative sector, with values less than 5,000 inhabitants/km^2 in areas of Kiselef Boulevard and Ferentari and Cotroceni neighbourhoods, up to over 40,000 inhabitants/m^2 in the crowded areas of Pantelimon, Titan, Berceni, Militari and Colentina neighbourhoods [17].
Based on the data obtained from the territory investigation, the irrigation elements have been determined. They were the basis for the calculation of the irrigation system for flowers, trees, shrubs, and lawn in Bucharest Plain by using the "Soil Water Balance Method", (Tables 3-5).
The irrigation elements have been calculated using the soil hydro-physical properties which are specific to Bucharest Plain and the city of Bucharest. They have been determined and calculated, according to the methodology developed by ICPA, on the thickness of the active layer of soil which is characteristic to the area (loamy and clayish reddish brown soil), without the addition of groundwater. Their values are summarized in Table 2.

Table 1. Hydrological regime of major rivers in Plain Bucharest

No. Crt.	River	Hydrometric station	The length of river (km)	Area (km2)	Annual average flow (m^3/s)	Monthly flow to ensure: (m^3/s)			Qm/QM (m^3/s)
						80%	90%	95%	
1	Sabar	Poenari	111	883	2.294	0.4	0.32	0.26	0/2.294
2	Sabar	Vidra	157	1212	8.443	0.368	0.14	0.084	0.06/8.443
3	Ciorogârla	Bragadiru	44	103	5.362	0.095	0.045	0.036	0.024/5.362
4	Colentina	Colacu	38	150	0.586	0.018	0.01	0.007	0.006/0.586
5	Dâmboviţa	Dragomireşti	241	1391	0.601	0.011	0.005	0.002	0/0.601
6	Argeş	Grădinari	243	3830	21.786	10	8.5	7.9	0.12/21.786
After: Adminsitraţia Naţională "Apele Române", Administraţia Bazinală de Apă Argeş-Vedea [18]									

Table 2. Hydrophysical indexes of soil in Bucharest Plain and Bucharest city

Ecosystem	Vegetation	Active thickes of soil layer	Apparent density (Da)	Wilting coefficient (CO)		Water field capacity (CC)		Active humidity range (IUA=CC–CO)		Minimum limit of humidity (p.min)	
		(m)	(t/m^3)	% gr.	m^3/ha	% gr.	m^3/ha	% gr.	m^3/ha	% gr.	m^3/ha
Flowers	15.04-31.09	0.40	1.44	12.40	893.00	23.50	1692.00	11.10	799.00	19.80	1425.67
Trees and shrubs	01.04-31.09	0.75	1.46	12.80	1270.67	23.23	2255.33	10.43	984.67	19.76	1927.11
Turfgrass (lawn)	01.04-31.09	0.75	1.46	12.80	1270.67	23.23	2255.33	10.43	984.67	19.76	1927.11

Table 3. Calculation of monthly and annual irrigation water needs of flowers in Bucharest Plain and Bucharest city

Statement (Vegetation:15.04-30.09)	**Month**						
	IV	**V**	**VI**	**VII**	**VIII**	**IX**	**IV – IX**
Monthly ETRO (m^3/ha)	285	1085	1470	806	1209	990	5845
Monthly rainfall (m^3/ha)	185	429	601	489	390	405	2499
Groundwater contribution (m^3/ha)	-	-	-	-	-	-	-
Deficiency (-) (m^3/ha)	100	656	869	317	819	585	3346
Excess (+) (m^3/ha)	-	-	-	-	-	-	-
Water balance in soil (m^3/ha)							
Original reserve of water - Ri	1293	1444	1537	1419	1601	1532	1293
Final reserve without irrigation – Rf (Ri + E) or (Ri – D)	1194	787	669	1101	782	947	-
Minimum limit of humidity	**1426**						
Water needs (Pmin – Rf)	232	638	757	324	644	478	-
Amount of watering norms - Σm	**250**	**750**	**750**	**500**	**750**	**500**	**3500**
Final reserve with irrigation – Rfi (Rf + Σm)	1444	1537	1419	1601	1532	1447	1447
Watering dates (day of the month) **$T_1 = (R_i - p_{min})/(ETRO_z - P_z)$** **$T_2 = T_1 + m/(ETRO_z - P_z)$**	-8	1	2	-7	-6	3	-
	-	9	7	11	8	11	-
	-	17	12	-	15	-	-
	15.IV;	01;09,17.V;	02;07;12.VI;	01;11.VII;	01;08;15.VIII;	3;11.IX;	14 waterings
Review	Σm = ETRO + Rf – Ri – Pv					Σm=	3500

Table 4. Calculation of monthly and annual irrigation water needs of trees and shrubs in Bucharest Plain and Bucharest city

Statement (Vegetation:01.04-30.09)	Month						
	IV	V	VI	VII	VIII	IX	IV – IX
Monthly ETRO (m^3/ha)	660	868	1230	1612	1426	750	6546
Monthly rainfall (m^3/ha)	371	429	601	489	390	405	2684
Groundwater contribution (m^3/ha)	-	-	-	-	-	-	-
Deficiency (-) (m^3/ha)	289	439	629	1123	1036	345	3862
Excess (+) (m^3/ha)	-	-	-	-	-	-	-
Water balance in soil (m^3/ha)							
Original reserve of water - Ri	2370	2081	2042	2213	1889	2053	2370
Final reserve without irrigation – Rf (Ri + E) or (Ri – D)	2081	1642	1413	1089	853	1708	-
Minimum limit of humidity	1927						
Water needs (Pmin – Rf)	-	286	514	838	1074	219	
Amount of watering norms - Σm	**-**	**400**	**800**	**800**	**1200**	**400**	**3600**
Final reserve with irrigation – Rfi (Rf + Σm)	2081	2042	2213	1889	2053	2108	2108
Watering dates (day of the month) **$T_1 = (R_i - p_{min})/(ETRO_z - P_z)$** **$T_2 = T_1 + m/(ETRO_z - P_z)$**	-	6	3	6	-1	5	-
	-	-	13	14	10	-	-
	-	-	-	-	19	-	-
	-	06.V	03;13.VI	06;14.VII.	01;10;19.VIII	05.VIII	9 waterings
Review	Σm = ETRO + Rf – Ri – Pv					Σm= 3600	

Table 5.Calculation of monthly and annual irrigation water needs of turfgrass (lawn) in Bucharest Plain and Bucharest city

Statement (Vegetation: 01.04-30.09)	Month						
	IV	**V**	**VI**	**VII**	**VIII**	**IX**	**IV – IX**
Monthly ETRO (m^3/ha)	420	1054	1440	1674	1364	780	6732
Monthly rainfall (m^3/ha)	371	429	601	489	390	405	2684
Groundwater contribution (m^3/ha)	-	-	-	-	-	-	-
Deficiency (-) (m^3/ha)	49	625	839	1185	974	375	4048
Excess (+) (m^3/ha)	-	-	-	-	-	-	-
Water balance in soil (m^3/ha)							
Original reserve of water - Ri	2145	2096	1871	1832	1846	2072	2145
Final reserve without irrigation – Rf (Ri + E) or (Ri – D)	2096	1471	1032	646	872	1697	-
Minimum limit of humidity	**1927**						
Water needs (Pmin – Rf)	-	457	895	1281	1055	230	-
Amount of watering norms - Σm	**-**	**400**	**800**	**1200**	**1200**	**400**	**4000**
Final reserve with irrigation – Rfi (Rf + Σm)	2096	1871	1832	1846	2072	2097	2097
Watering dates (day of the month) **$T_1 = (R_i - p_{min})/(ETRO_z - P_z)$** **$T_2 = T_1 + m/(ETRO_z - P_z)$**	-	5	-1	-2	-2	6	-
	-	-	10	9	10	-	-
	-	-	-	17	19	-	-
	-	5.V	1.10. VI	01;10,1 7.VII	01;10;19. VIII	06.IX	10 waterings
Review	Σm = ETRO + Rf – Ri – Pv					Σm= 4000	

Subsequently, the irrigation system installation technical plans shown in Fig. 4 and Fig. 5 and Summary Table (no. 6) of the irrigation system operating program prepared on the basis of the functional parameters of watering equipment, which are the system components, have been drawn up according to the irrigation data.

The irrigation system installed for watering the plants in the Dobroiesti ecological park of the capital, shown in Fig. 3, has been designed based on certain operation limiting factors, that is the large area of land, its shape and slope, the flow available to water (13 m^3/ha) and its pressure in the water supply pipe (55 mca). Thus, the irrigation system was designed to operate in order to implement a gross irrigation standard (average of the gross watering standards of constituent ecosystems) of 350 m^3/ha, by administering a daily irrigation water volume of 15 l/m^2 with a daily operating time of 21 hours in three consecutive rounds, 3 calendar days respectively.

Fig. 3. Layout of the Dobroiesti ecological park

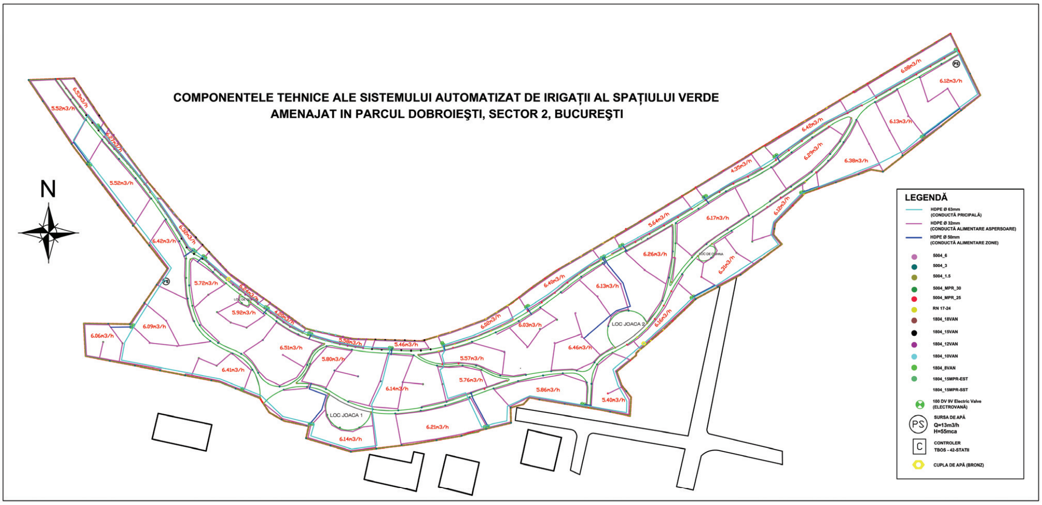


Fig. 4. Layout of pipes, flow areas and watering equipment location of the Dobroieşti irrigation system

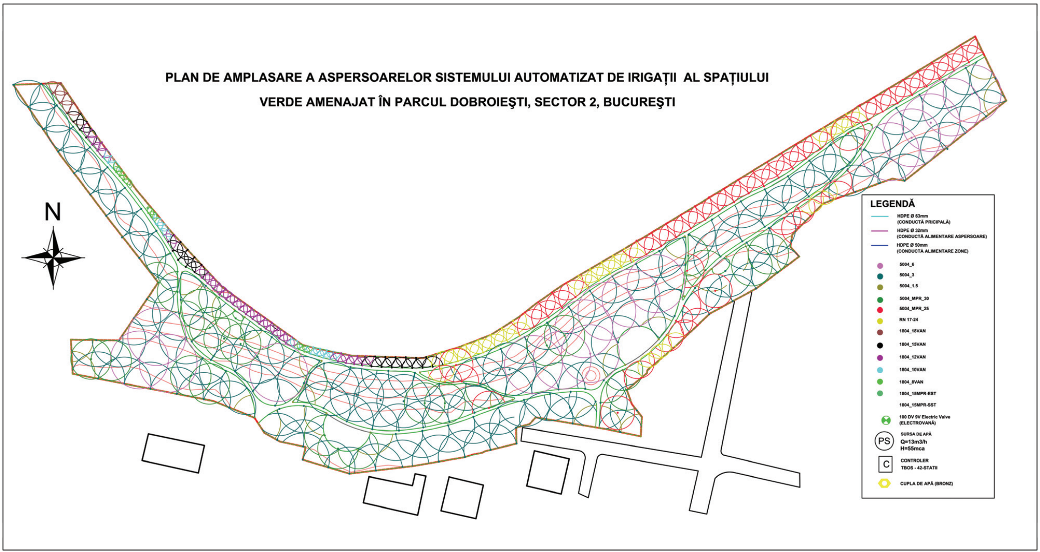


Fig. 5. Angle range and location plan design of sprinklers of the Dobroieşti irrigation system

Table 6. Operation features and technical parameters of watering equipment designed and executed in green park Dobroieşti

Total area for irrigation 20.000 m^2	**Gross watering standards (watering norms) - m**			**m^3/total green area f(m)**
	Ecosystem	**m^3/ha**	**l/m^2**	
Daily irrigation water volume 15,00 l/m^2	Flowers	250	25	500
	Trees and shrubs	400	40	800
Minimum water supply parameters 13 m^3/h; 55 mca	Turfgrass (lawn)	400	40	800
	Average standards (norms)	350	35	700

Nozzle type	**Sprinkler type**	**Range / Sector**	**No. pcs.**	**Sprinklers neto water consumption (m^3)**	**Nozzle flow* (m^3/h)**	**Nozzle rainfall * (mm/h)**	**Sprinkler operating time (min./day)**
18VAN_Q	Spray	5.5m / 90 degrees	2	0,18	0,30	50	18,0
18VAN_H	Spray	5.5m / 180 degrees	6	1,08	0,60	50	18,0
15VAN_H	Spray	4.6m / 180 degrees	25	3,15	0,42	50	18,0
12VAN_H	Spray	3.7m / 180 degrees	45	4,05	0,30	50	18,0
10VAN_H	Spray	3,1m / 180 degrees	20	1,24	0,33	80	11,3
8VAN_H	Spray	2,4m / 90 degrees	16	0,81	0,27	80	11,3
15EST	Spray	1,2m x 4,6m streak	2	0,08	0,14	50	18,0
15SST	Spray	1,2m x 9,2m streak	4	0,32	0,27	50	18,0
RN17-24H	Multijet	6m / 180 degrees	39	11,99	0,41	20	45,0
5004-6.0	Rotor	13.6m / 30-360 degrees	14	17,59	1,34	16	56,3
5004-3.0	Rotor	12.1m / 30-360 degrees	154	132,83	0,69	12	75,0
5004-1.5	Rotor	10.6m / 30-360 degrees	22	14,03	0,34	8	112,5
5004_30_H	Rotor	9.1m / 180 degrees	18	10,05	0,67	18	50,0
5004_30_F	Rotor	9.1m / 90 degrees	14	15,40	1,32	18	50,0
5004_25_F	Rotor	7.6m / 360 degrees	4	2,90	0,87	18	50,0
5004_25_H	Rotor	7.6m / 180 degrees	67	25,13	0,45	18	50,0
5004_25_Q	Rotor	7.6m / 90 degrees	2	0,38	0,23	18	50,0

Volume of irrigation water necessary every day (m^3):	241,20	m^3
Time spent every day irrigation (hours):	21	hours
Number of days allocated for the application of a gross watering standards:	3	days
Pumping capacity (13% reserve for pumping capacity)	13	m^3/h
System performance index	1,29	

*after Rain Bird[19] catalog for placement in square with a 1/2 overlap diameter at the designed pressure (sprinkler working pressure: 3.0-3.1 bar for rotors and amd 2.1 bars for sprays

These data have been determined by correlating the time of operation of sprinklers in relation to the rain-measurement and flow of nozzles, at a working pressure of the sprinkler of 3 and 3.1 bars for rotors and 2.1 bars for sprays, as presented in Table 6.

According to the calculations, namely the summation of net water consumption of all sprinklers, a total volume of 241.20 m^3 of irrigation water needed to be distributed throughout the entire area (2 ha) has resulted.

To administer a gross watering standard, the time required for applying the 3 calendar day rule has been calculated, which led to the establishment of a system performance index of 1.29.

This index reflects the fact that the system provides in certain areas a larger quantity of water than that provided by the watering standard. Given the pronounced slope of the land, this is not a negative effect on plants, since the intensity of irrigation is inferior to the speed of soil water infiltration.

Thus, according to the data presented in Table 6, the optimal operation of solenoid valves serving the system watering wings (areas) are:

- 18 minutes / day in areas whose majority components include the spays equipped with nozzles series 18 NAV, 15 NAV, 12 VAN, 15 EST and 15 SST;
- 11 minutes for areas whose majority components include the spays equipped with nozzles series 10 VAN and 8 VAN;
- 45 minutes for areas whose majority components include the spays equipped with revolving nozzles series RN 17-24;
- 56 minutes for areas whose majority components include the rotors 5004 equipped with nozzles series 6.0.

CONCLUSIONS

The area chosen for the research on the landscape development with irrigation systems has been analyzed in terms of landscape, determining the local pedoclimatic conditions, in close connection with the site location and the compliance with the prevailing landforms, natural vegetation, geological structure, hydrology, hydrogeology and social and economic and demographic elements.

Based on the pedological and geological structures of the area, the soil hydro-physical properties determined according to the protocol developed by ICPA, depending on the soil active layer thickness and subsequently determined by the watering standards, have been established.

Applying the soil water balance method, using as input data the average useful rainfall during the growing season, the monthly actual evapotranspiration optimal values (ETRO), the soil water supply and monthly and annually irrigation water demand, the number of necessary watering, the theoretical irrigation standards and the watering time have been established for the three studied ecosystems, as they are presented in Table 7.

These values proved useful since the design phase, for determining the irrigation system operating programs and the volumes of distributed water.

Table 7. Review of the irrigation regime elements in Bucharest Plain and Bucharest city

No. crt.	Plants/ Ecosystem	Watering standards (norms) (m^3/ha)		Watering dates	No. of waterings	Irrigation norms - Σm (m^3/ha)	
		neto	bruto			neto	bruto
1.	**Flowers**	213	**250**	15.IV; 01;09,17.V; 02;07;12.VI; 01;11.VII; 01;08;15.VIII; 3;11.IX;	14	2982	3500
2.	**Trees and shrubs**	380	**400**	06.V; 03;13.VI; 06;14.VII; 01;10;19.VIII; 05.VIII	9	3420	3600
3.	**Turfgrass (lawn)**	380	**400**	5.V; 1.10.VI ; 01;10,17.VII ; 01;10;19.VIII ; 06.IX	10	3800	4000

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