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Irrigation

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1. Introduction

The water is basic source for all living in the world and it covers two third of the earth, it is the lifeblood of plants and its permanent of temporary shortage can cause serious damage to plants yield and quality. However, despite the importance of water for the continuation of life, 97.5 % of existing water is in ocean and high seas water that cannot be used. The remaining just 2.5 % is fresh water and can be used by living things; however, the vast majority, like 90% of this fresh water is in the poles and underground water and it doesn't have usable form (William, 2007). Available water resources in the world not showing continuity in time and space, the increasing effect of global warming and the three main water users (agriculture, industry and domestic sectors) creating a growing demand and pressure for water supply increases the importance of water.

Irrigation has an important place in terms of water usage, its environmental impact and reuse of urban waste water. Irrigation; firstly begin with people becoming sedentary and agricultural practices, it has been made to improve the quality and quantity of crop production. Especially since the 1950s, people living in the cities started to be the owner of a garden, studies conducted in the urban landscape water is needed in these areas with different types of grass and ornamental crops, in order to ensure the sustainability of irrigation, which resulted in entering of irrigation into urban life. Today, irrigation emerges as an indispensable element in Landscape architecture.

2. Irrigation water quality and reuse of waste water for irrigation

2.1 Irrigation water quality

Irrigation water quality is important for two reasons for irrigation engineers. The first , depending on the quality, irrigation method and irrigation system components are determined, the needed additional equipment lead to an increase in total cost of the system. The second, water quality affects adversely plant growth and soil fertility after the system operates. Irrigation water characteristics are examined in three groups; physical, chemical and biological (Wilko & Short, 2007).

2.1.1 Physical properties

In the physical properties, suspended matter is one of the most important features. Suspended matters in natural waters are usually composed of plaques erosion, parts of organic matter and planktons (Ayyıldız, 1990). Suspended matters are one of the most important things because they could cause obstructions in emitters in the sprinkler and drip irrigation. This kind of water should be filtered appropriately and then should be given to the system.

2.1.2 Chemical properties

The most important chemical properties in terms of irrigation is pH, the amount of solid matter dissolved in water (electrical conductivity), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), Na % and amount of boron. pH is a measure that shows the acidity or alkalinity of water and it is required to be between 6.5 to 8.0 in irrigation water. The amount of dissolved solids is the degree of salinity in irrigation water. The degree of salinity in irrigation water is expressed as electrical conductivity (Ayyıldız, 1990). Salt in the irrigation water is important in terms of physical and chemical properties changes of the water and soil, making toxic and physiological effects on plant. Most water of acceptable quality for turfgrass irrigation contains from 140 to 560 μmhos/cm soluble salts (Cockerham & Leinauer, 2011). It is necessary to be careful when irrigating with highly salinity waters, especially higher than 2250 μmhos/cm.

Sodium is important in terms of blocking soil colloids and prevents the formation of a available air water balance in the soil. Ratio of sodium ion on total cations (Na %) and its ratio to magnesium and calcium ions (SAR), the two indicators are used in evaluation of irrigation waters. In order to create a condition of suitable soil in the root zone of the plants, the percentage of Sodium should not be more than 50-60%.

Sodium adsorption ratio is another important factor. As the increase of the sodium amount in the irrigation water breaks its physical properties, it is also important in terms of making alkaline the soil (Smith, 1996). In the analysis of irrigation water, due to the higher total salt concentration the higher effect of SAR will be, while estimating the effects of the SAR, the total concentration in the irrigation water should also be considered.

Boron is another important criterion, which is usually not available as element in nature, it is usually found as sodium borate or calcium borate. More than 0.5 mg/l in irrigation water may cause toxic effect on plants.

2.1.3 Biological properties

Because of bacteria threaten the human health, care should be paid in the use of such polluted water in areas where people live. As specified in the regulation of water quality, the fecal coliform values up to 200/100 ml of water can be used for irrigation purposes (Harmancioglu et. al., 2001).

2.2 Reuse of waste water in irrigation

Water is polluted physically, chemically and bacteriological by various wastes especially in industrial and agriculture as well as household use. Water contaminated in such ways is called waste water. In the regions where clean water resources is limited or water charges are high, irrigation water requirements are tried to be solved with the use of waste water contaminated with industrial and specially with urbane use (Novotny et. al., 2010). However it should be remembered that the waste water can be used for irrigation purposes if it is treated to the degree that it meets the quality regulations and communiqués criteria. In case of irrigation with waste waters, it is essential to identify an irrigation method and program that will no cause pollution of clean water as a result of deep seepage or runoff. Especially before using bacteriological contaminated waste water for landscape irrigation, the size of the area, population density, pollution degree of water must be analyzed very well (Surampalli & Taygi, 2004). Drip irrigation method should be preferred to sprinkler irrigation in order to minimize the damages to the people around since water is applied to the plants through atmosphere in sprinkler irrigation and to prevent black logs on the plant during irrigation of polluted waters. If sprinkler irrigation method is required to be applied, irrigation will possibly minimize the health and environmental effects in windless conditions.

3. Quantitative characteristics of irrigation water

3.1 Evapotranspiration

Plants, like all living things require water to sustain their lives. In order to fulfill the basic functions, enough water is needed in the soil containing roots. Otherwise, plant growth decline and deaths occur in later stages. Evapotranspiration (ETc) is consisting of two basic elements. These are: transpiration through stoma of plant leaves and evaporation of open surface of the soil around the plant. Many ways including direct and indirect ways are used in determination of ET. However, reference evapotranspiration (ET_0) are used as pre-projecting factor reference. A mathematical relationship is used for this purpose as given bellow. (Doorenboos and Pruit, 1977):

$$ETc=ETo*kc \quad (1)$$

Where,
ET_c: Evapotranspiration of the crop, mm
ET_o: Reference evapotranspiration, mm
k_c: crop coefficient

ETc is calculated based on plant that is taken as reference in ET_o. This plant is usually alfalfa or meadow pasture. There are many improved equations to calculate the reference Evapotranspiration. These include Penman FAO modification, Penman Montheith, Hargraves, Blaney Criddle and Class A evaporation tank etc. (Tekinel and Kanber, 1988).

The second factor affecting the Evapotranspiration is crop coefficient. Crop coefficient is defined as a ratio of ETc to ETo. Crop coefficient varies depending on factors such as plant type, age, growth period, soil moisture etc (Allen et. al., 1978). Grass plant is usually grown in the fields of landscape. Although this plant has many types, its k_c value has been reported to vary between 0.7 and 1.05.

3.2 Net irrigation requirement

Surface water resources are not distributed in a homogeneous way in many regions of the world, irrigation is applied in these areas in order to ensure vegetation sustainability due to irregular and inadequate rainfall. Irrigation water requirement is calculated with the help of the following equation.

$$IR: ETc-Peff \quad (2)$$

Where,
IR= Net Irrigation requirement, mm
ET_c= Evapotranspiration, mm
P_{eff}= Effective rainfall, mm

The irrigation requirement occurred as a result of evapotranspiration can be meet by precipitation. Precipitation usually occurs in the form of rain in plant growing season. Therefore, in determining of irrigation water requirement, the rainfall used by plants must be taken into account. However, a certain amount of rainfall is used by plants through surface runoff and deep infiltration. The rainfall that is stored and used in the root zone of the plants is called effective rainfall.

3.2.1 Net irrigation requirement for each irrigation

In the irrigation scheme, in the event that evapotranspiration is not met with natural rainfall, the deficit should be met with irrigation. In a operation unit, the quantity of irrigation water is determined with the help of the following formula.

$$dn=(FC-WP)/100)*Ry*\Upsilon t*D \quad (3)$$

Where,
dn**:** Net irrigation requirement for each irrigation, mm
FC= Field Capacity, %
WP= Wilting point, %
Ry= Allowable soil water deficit % (0.3-0.4 can be taken for turf)
ϒt= bulk density, g/cm^3
D= the root depth, mm

As shown in the equation 3, there are two basic features affecting quantity of irrigation water. These are soil and plant features. In the irrigation area, due to the fact that the plants in each operation unit have different evapotranspiration, the quantity of the bounden irrigation water is also changing. At the same time, depending on soil characteristics, the water-holding capacity representing the rest quantity of water between field capacity and wilting point, also changes while water-holding capacity is low in a sandy soil, it is high in a clayed soil. In contrast to the sandy soils, due to the high water-holding capacity of clayed soils, more irrigation water will be applicated. Therefore, in the preparatory stages of recreation areas, when creating operation units, ensuring the collection in the same area of the same kind of plants and the fields with the soil structure will provide great convenience to users in the operation of irrigation system. This planning is the only way to ensure the uniform water distribution in the system without causing the overuse of excess water. In case of ignoring this situation, in the operation units that exits different plants or they are nested, some plants will be overwatered, and also some plants will be watered insufficiently. In addition, depending on soil characteristics, while the pondings may be in some areas, there will be losses of deep-seepage in some areas.

3.2.2 Gross irrigation requirement for each irrigation

Even in optimal projecting condition, there is no storage of all of the water in the root zone of plants. During the delivery and application of irrigation water, the water losses are experienced. It is considered that there is no delivery losses in water pipes transmitted with closed pipes. The total quantity of the required irrigation water for each irrigation is calculated by the following formula.

$$dg=dn/Ea \tag{4}$$

Where,
d_g: gross irrigation requirement, mm,
d_n: net irrigation requirement, mm,
E_a: irrigation application efficiency %.
E_a can be taken as 0.8 when the planning for sprinkler irrigation

3.2.3 Irrigation interval

It is an expression how many days elapsed between consecutive two irrigation. It can be determined with the help of the following formula.

$$Ti: dn/Etc \tag{5}$$

Where,
Ti: irrigation interval, day
d_n: Net irrigation requirement for each irrigation, mm
ET_c: evapotranspiration mm /day

Due to heavy textured soils have greater water-holding capacity, the irrigation interval increases depending on the net irrigation water, and it decreases in sandy soils. In suitable soil conditions, as reducing by half the irrigation period of a week or ten day period of irrigation, increasing irrigation efficiency can be achieved.

3.2.4 System capacity

The system capacity turned from water supply or irrigation duration is determined by the following formula.

$$Q=A*dt/3.6*T \tag{6}$$

Where,
Q:System capacity, L/s
A: Irrigated Area, da
T: Irrigation duration, h

4. Irrigation methods

The way of irrigation water supplied to the crop root zone is called as irrigation method. In determining the irrigation method for use, soil and topographic features of the land, plant type, irrigation water supply, labor and technical skills conditions, facilities and operating costs and climatic data of region are factors that are needed to be considered. Basically, there are two groups as surface irrigation methods and pressurized irrigation methods. Surface irrigation methods are evaluated amongst the traditional irrigation methods and transmission of water is carried out with the help of energy provided through geographic height difference completely between the source and target parcels. The basin, furrow, border and uncontrolled flooding irrigation methods are also involved in the surface irrigation method.

The purpose of Irrigation planners is to re-increase the optimum level the decreasing water levels in the root zone with a minimum of irrigation water by using an efficient irrigation system. The pressurized irrigation methods are preferred than surface irrigation methods because of its need more less water and staff per unit area. In pressurized irrigation methods, water is transmitted via the pipe system from the source to the relevant parcels under a certain pressure. A pressurized irrigation system that will be installed in general, is composed of pump unit, control unit, the main pipe line, sub main pipe line, manifold, lateral and water emitters (Phocaides, 2007) (Figure 1).

4.1 Sprinkler irrigation

This method is the systems which water is supplied from the source such as stream, lake, dam, or drinking water system in the form of droplets sprayed through atmospheric air to the plant with the help of sprinklers (Ingels, 2003). These types of systems which are high degree-uniform-water distribution can be supplied with proper planning in all kinds of soil conditions and slope and rough terrains. Sprinkler irrigation is the most suitable and common method for landscape irrigation. It is suitable for irrigation by using any type of water source on the condition of using appropriate equipment. Sprinkler irrigation elements: water supply, pumping unit, control unit, the main canal, sub main canal, manifold, lateral and sprinkler heads. Sprinkler irrigation method is the most preferred method in landscape irrigations. Advantage and disadvantage of sprinkler irrigation method are given below.

The advantages of sprinkler irrigation method

- The larger areas can be irrigated with smaller quantity of water than the method of surface irrigation.
- In problematic areas from topographic aspect, the desired performance can be achieved through appropriate design and arrangement.

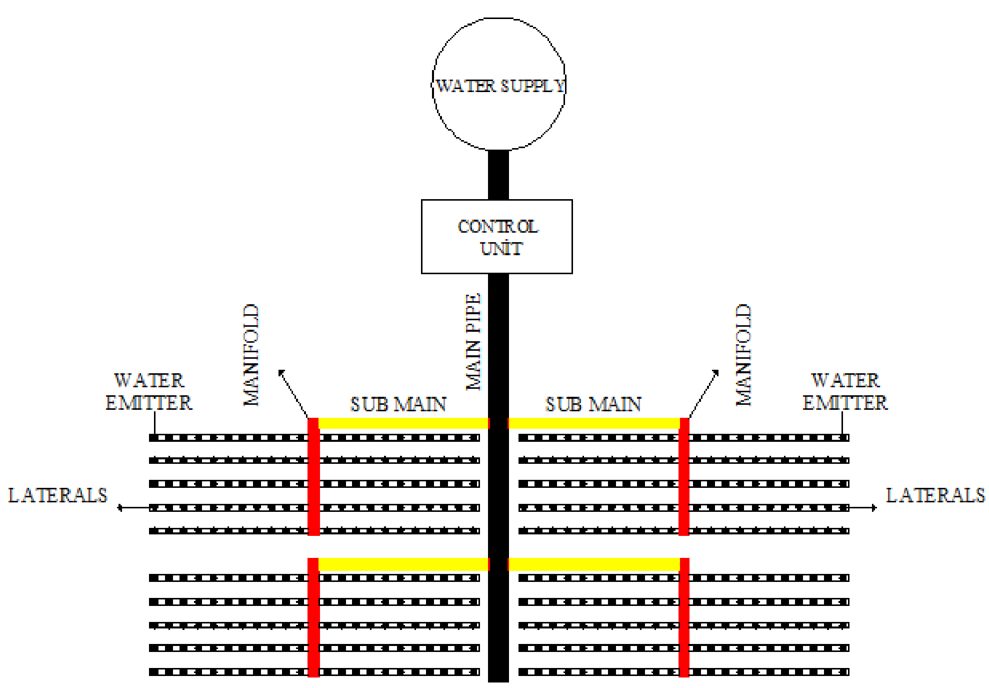

Fig. 1. Main components of pressurized irrigation systems

- High uniform distribution of water can be provided,
- Irrigation efficiency is high,
- Fertilizing can be applied during irrigation,
- Frost protection can be achieved.
- Irrigation labor is less than in surface irrigation.
- Its initial investment cost is lower than the drip irrigation.
- It prevents the salt deposit in the root zone of plants by the effect of leaching

The disadvantages of sprinkler irrigation method

- The realization problems of uniform distribution of water are experienced especially in windy conditions.
- Blasts may occur in the leaves in applications during sunny conditions
- It leads the occurrence of an illness (crown gall) or spread of disease in the wet foliage
- The evaporation loss is occurred at noon.

Components of sprinkler irrigation system are given below.

4.1.1 Water supply

In sprinkler irrigation systems, rivers, lakes, well water, dam can use as a source of water. Urban drinking water schemes and wells are generally used in Landscape irrigation.

4.1.2 Pump units

In sprinkler irrigation system, water should be sprayed from the headings under a certain pressure. This pressure is called as a head-operating pressure. In addition in the system, depending on equipment used between water supply and irrigation area, in case of an extra pressure requirement due to the difference of levels with terrestrial and permanent head loss, this requirement is met by pumping station that will be installed on the system. The pump units can be electric or diesel engines. Centrifugal pumps are suited if the height between the pump and the water supply is less than 8 m if not deep well pumps are suited.

4.1.3 Head control

The head control unit that is located between the water supply and the delivery line, is composed of hydro cyclone, sand and gravel filter, fertilizer unit, mesh filter and pressure regulator from the pump to main pipe line. In addition, the components such as check valve, a shut-off valve, pressure gauge, water meter and the equipments such as the nipple, ell and tee combining these components are involved.

4.1.3.1 Fertilization unit

In areas where sprinkler irrigation systems are installed, the fertilization process can be carried out with the aid of a pump unit such as venture tubes or injection pumps, the fertilizer tank that will be placed in head control unit. Due to different fertilization requirements of different plants, this process is used more easily and effectively in areas where there is especially the only type of plants such as grass fields.

4.1.3.2 Filter

Depending on the source of water used in sprinkler irrigation system, irrigation water contains substances that can clog heads such as silt and organic matter. The filtration is performed to prevent clogging problems in short-and long-term in the system. Depending on the nature of water resources, it can be used to avoid clogging the heads of sand separator, hydro cyclone and disc filter. Due to mostly use of drinking water for landscape irrigation, filtering process is carried out with the disc or mesh filters. In sprinkler and drip irrigation systems, 80-120 mesh filters are usually preferred.

4.1.3.3 Valves

The sprinklers are the equipments which the water quantity supplied to the processing and accordingly are used to adjust the pressure in irrigation systems. In general, the valves divided into manual and automatic valves. Manual valves can be listed as ball valves, gate valves, butterfly valves. In landscape irrigation, irrigation control is carried out with the help of automatic valves. The control valves used in the different points of landscape control the direction to various processing of the water in the system according to different requirements (Figure 2). The check valves that are installed sprinkler heads, they prevent back flow of water when the system is turned off.

Fig. 2. Control Valve and Application Sample

4.1.3.4 Pressure gauge

Operating pressure of sprinkler head within system requires to be obtained steady. Since changes such as increase or decrease to be occurred in operating pressure affect flow value to be ejected by heads, they prevent corresponding water diffusion from being provided. Due to over pressure to be applied in irrigation units, it causes occurrence of breakdown. In addition, probability of occlusion in fertilization tank can be detected through pressure gauge placed in front of and at the end of fertilization tank. Thus, pressure value is constantly kept under control through manometers to be placed in system control unit.

4.1.3.5 Pressure regulators

Pressure regulators are equipments that provide irrigation in constant volume, preventing pressure fluctuation within system. Inappropriate choice of pressure regulator for system causes to be defected by loading excessively over system units. Also, irregular, inadequate or high pressure cause breakdown of corresponding water diffusion and unnecessary additional irrigation. Pressure regulator generally used in control unit may be used before manifolds in main systems if required.

4.1.3.6 Control units

Operating units generated in pressurized irrigation systems have possibility of being operated on time and duration which is desired by the help of control units. As well as control units are used in garden-type small irrigation area having only one operation, the more developed ones can be done by means of a program which can operate several operations at the same time if requested. Electrical or wireless models of control units are used in areas in which electrise is problematic (Orta, 2009). If required, program used can regenerate irrigation program again by help of rain, wind and soil sensors placed in control units. Shut-down of system can be obtained by itself on the instant of rain through programming rain shutoff on control units. Also, it can prevent irrigation in case of soil`s having enough moisture by programming soil moisture sensors (Cardenas-Lailhacar et. al., 2008). Moisture sensors to be installed within working area provide more economic use of water, generating irrigation program.

Fig. 3. Control unit panel having 8 Station used in landscape irrigation Systems

4.1.4 Delivery line

Consist of pipes which deliver irrigation water from pump units to water emitters. A typical delivery line consists of main and lateral pipes and equipment which are used to tie those pipes. But submain and manifold are also included in great irrigation area.

4.1.4.1 Main line

They are pipes which transmit water from control units of water to submain canals if any, or to manifolds. Main canals carrying highest flow in system are manufactured as PVC and PE. Generally, 63-160 mm diameters are used depending on the size of system. They are the pipes in which frictional loss is at the most.

4.1.4.2 Submain line

Submain pipes are the same type of pipes with main pipes. The highest cost in irrigation systems is cost concerning pipes and mainly main pipes. In choosing of irrigation pipes, pipes which have minimum capacity to meet requirements of flow in system should be chosen. By purpose of water distribution to be provided in different regions in major irrigation systems, dimensions of pipes are changed from a point which is broken into pieces from main pipes and by this way, disposals can be provided, using pipes which carry as need. These pipes transmit water taken from main pipes to manifolds.

4.1.4.3 Manifold line

Manifolds placed under soil are smaller-scale pipes as compared to sub main pipes as other pipes. Manifolds are placed vertical to parcel edges and maintain laterals. Manifolds mostly consist of HDPE pipes.

4.1.4.4 Lateral line

They are the smallest scale pipes within system. Lateral pipes are responsible for transmitting water from manifold pipes to sprinkler pipes. Laterals are placed under soil in landscape irrigation. All pipes in system are tied to each other by help of connectors.

4.1.5 Sprinkler heads

The most important parts of sprinkler irrigation system are certainly sprinkler heads. Sprinkler heads are placed at certain intervals over laterals. As well as sprinkler heads is placed on a riser over lateral, they are generally embedded underground in landscape irrigation and known as pop up. Pop up heads do irrigation, moving over soil surface when water is given in system. There is two type of sprinkler heads divided as spray and rotor. Spray heads irrigating without turning are used for confined space (Figure 4). Wetting dimensions of them are 2-4.5 m and working pressures are 1-3 bar (Orta, 2009). Spray heads throw water in higher amounts in more narrow space as compared to rotor. Rotors are used in wider areas with lower precipitation rate (Figure 5.). Rotor type heads are generally used in landscape irrigation. Unit price of spray heads are lower as compared to price of rotor heads but facility costs of sprays are higher as compared to the ones of rotors. Factors such as soil infiltration rate, type of plant, wind conditions, limitations of pressure, demands of owner of system should be taken into account in choice of heads. Also, lowest flow of system, low operating pressure and widest spacing of sprinkler head are considered while making a choice between heads which can meet necessary requirement of water in system. Technical properties related to pop up head are presented in schedule (Table 1).

4.1.6 Water distribution in sprinkler irrigation method

Water throws towards to air at a certain angle in sprinkler irrigation. As a result of this, head as being in center, causes a circular area to be wetted. This area is called as wetting area of sprinkler head. Big water grains drop around head during irrigation and size of water grains dropping over soil get smaller as head goes far. Each head constitute a water distribution depending on dimension of orifices over which each head is equipped and operating pressure (Melby. 1995). In case of head pressure`s decreasing under optimum pressure or increasing it causes deformation of water distribution in Figure 6. Changes of water distribution under different pressures are given Figure 6.

Fig. 4. Samples of using spray

Fig. 5. Samples of using Rotor

It is not possible to provide uniform distribution in irrigating area by singular heads in sprinkler irrigation system. Uniform distribution is obtained by using more than one heads. Factors which affect water distribution are the sprinkler nozzle, operating pressure, flow rate, speed & uniformity of rotation, spacing of the sprinklers, pattern of the sprinkler grid and wind. What is required to be done after choice of appropriate head by purpose of providing uniform distribution is defining sprinkler pattern and sprinkler space. Heads are commonly lay out in shapes of triangle, square and rectangular. Triangular shape is used most commonly in landscape irrigation. In choice of triangular shape better water distribution is obtained in areas having equilateral triangle as compared to square shape. Water disposal is obtained in decreasing waste water due to its water distribution pattern `s being better as compared to square shape. Head in less numbers are used since sprinkler heads are placed to more distant area in triangular shape. Triangular shape presents better performance in irregular areas as compared to square shape (Melby. 1995). Another factor is distance between heads. For a good water distribution head intervals on lateral shouldn`t be more than 50% of dimension of wetted area. Also lateral intervals affect water distribution.

Lateral intervals in line of main pipes shouldn`t be over 65% of wetting area. Technical charts presented by producing company are available for each head. In these charts head flows and wetting area in different orifice dimensions and operating pressure are stated. These charts are used in choice of appropriate heads in irrigation area (Yıldırım. 2008).

Nozzle Model	Pressure (Psi)	Radius (m)	Flow (l/min)	Precip. ϒ (cm/h)	Precip. Δ (cm/h)
360°	1.4	2.1	6.51	6.58	9.59
	2.1	2.1	8.06	8.13	9.40
	2.8	2.7	9.39	9.47	10.95
	3.4	2.7	10.52	10.62	12.27
270°	1.4	2.1	5.15	6.93	8.0
	2.1	2.7	6.25	8.41	9.70
	2.8	2.7	7.15	9.63	11.13
	3.4	2.7	8.06	10.85	12.52
180°	1.4	2.7	3.29	6.65	7.67
	2.1	2.7	4.05	8.18	9.45
	2.8	2.7	4.66	9.40	10.85
	3.4	2.7	5.22	10.54	12.17
90°	1.4	2.7	2.0	8.10	9.35
	2.1	3	2.42	9.78	11.30
	2.8	3	2.73	11.00	12.70
	3.4	3	2.95	11.91	13.77

Table 1. Technical schedule related to pop up head

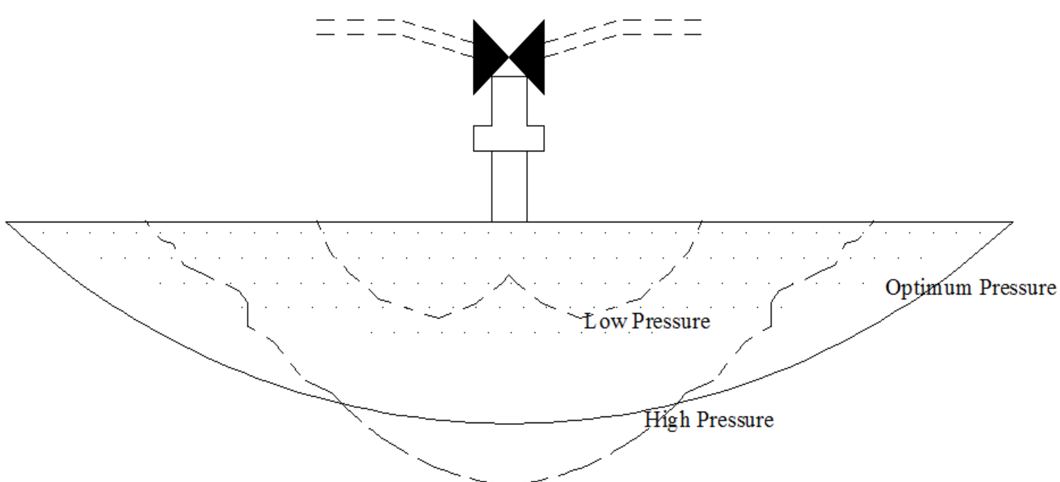

Fig. 6. Water distribution histogram obtained under different operating pressures (Gungor et. al. 2010).

Since sprinkler heads make irrigation by throw water towards to air at a certain angle they are highly affected from windy air conditions. By aiming at obtaining the best distribution in windy conditions by irrigation system a number of arrangements in choosing of sprinkler are required (Barrett et. al. 2003). These arrangements may help to perform a better distribution since water which is sprinkled from less wetting scale heads drop closer area and their interaction with contact of wind is less in areas which are exposed to wind excessively. Having the smallest throw angle should be used. Optimal throw angle is 32° for sprinkler irrigation under normal circumstances. However it is required to reduce this angle in windy conditions. Adjusting throw angle as 22-27° in areas where wind speed is higher than 2.6 m/sec shall give better results. However heads are required to be placed in a closer area for corresponding water distribution since fire distance is decreased in this case. Also laterals should be placed vertical to wind direction.

Water distribution uniformity is a parameter that questions situation of hydration of irrigated area with corresponding amount of water. This parameter is one of the main factors which is useful for decreasing system costs thanks to consume of less electric, water, fertilizer and pesticide in connection with its irrigation performance. Different parameters are used by purpose of determining uniformity of water distribution. Parameters which are commonly used are sprinkler uniformity Christiansen's coefficient of uniformity (CU), Distribution Uniformity (DU) and Scheduling coefficient (SC).

4.1.6.1 Distribution uniformity (DU)

Distribution uniformity is one of the methods which is preferred in determining uniformity in irrigated area. In this method, amount of precipitation is measured by means of caps placed in irrigated area. Then uniformity value is determined by estimating average catch amount belong to quarter which has least water with average catch amount of irrigated area (ASCE.1978). For example, 5 caps Where has the lowest catch amount represent average catch in the low quartile in a test where there are 20 measurement caps (Walker and Skogerboe 1987). Distribution uniformity (DU) should be greater than 75% and if greater than 85% is excellent and acceptable for any sprinkler irrigation. The value of Distribution Uniformity coefficient is calculated using the following expression.

$$DU=(MQl/M)*100 \tag{7}$$

Where.
DU: Distribution uniformity, %
M_{Ql}: Average collected volume of lower quarter of catch cans, l
M: Average collected volume of all catch cans, l
Distribution uniformity should be at least 70% in rotor heads and 50% in spray heads. As being different from DU, CU and SC parameters can be determined.

4.1.7 Christiansen coefficient of uniformity

Christiansen Coefficient of Uniformity is used commonly in irrigation sector. Christiansen (1941) developed a formula which depends on average value of irrigation water amount and standard deviation value which are measured through caps placed in irrigated area. CU is calculated by means of formula below.

$$CU=100((1-(\Delta \bar{q})/\bar{q})$$ (8)

Where.

CU: Christiansen coefficient of Uniformity, in %
$\Delta \bar{q}$: th average absolute deviation from the mean, m^3/h
$\bar{q}$: mean application rate, m^3/h

While evaluating CU parameters values which are over or under average are considered as similar. This coefficient is developed for agricultural areas and is not highly useful for turf area. Total variation is applied to define applications which are not uniform. However visual quality should be spread over all area in turf area (IA. 2003). CU values being higher than 84% are suggested as acceptable (Anonymous. 2009).

4.1.8 Scheduling coefficient

Scheduling coefficient helps us to define how much critical dry area shall be left in irrigated area and irrigation duration being necessary for its application to eliminate this area (Zoldoske. 2003). In calculation of SC. it is useful to be benefitted from computer program. Due to limitations in DU approach SC gains value especially in turf and golf industry (Wilson and Zoldoske, 1997). The driest area is usually user defined as 1. 2. or 5 percent of the coverage area. SC generally varies between 1.1 and 1.4. An efficient irrigation system should aim to achieve a scheduling coefficient less than 1.3.

$$SC = \text{Average catch overall} / \text{Average catch in the critical dry area}$$ (9)

4.2 Supplemental irrigation methods in landscape irrigation

Drip and micro sprinkler irrigation are used in areas here sprinkler irrigation is not appropriate in landscape irrigation. Drip irrigation system is installed in two different types such as under soil and over soil. Water is transmitted to root region through a pipe network and applied here by a means of drippers. Vaporization, runoff and deep seepage into deeper are prevented due to water`s implication by low flow rate in drip irrigation system. Therefore it is irrigation method of which application performance is the highest (Schwankl & Prichard. 1999). Also, drip irrigation minimizes sickness and insect damages because it makes irrigation without wetting leaves. It has less operating pressure. It applies water at fewer amounts as compared to sprinkler irrigation. Problem of weed occurs less because certain part of area is wetted. Also, drip irrigation performs at high efficiency without runoff on hilly terrain. This method is used in soils where area to be irrigated is narrow and saltiness ratio is problematic and resource for water is limited and soil is highly inclined in landscape irrigation (Dines & Brown. 2001).

Micro Sprinkler can be carried out by placing them singularly under trees in situation that drip irrigation can`t provide adequate wetting area. Throw distance of these heads is highly low. However, flow rates changes between 30-300 l/h. accordingly wetting ratio which is requested is provided in a more economic way. Micro sprinkler is developed by the purpose of linking good sides of sprinkler and drip irrigation system.

5. Planning stages of sprinkler irrigation systems

Steps of sprinkler irrigation project are carried out a number of calculations starting from choice of head and to flow of pump.

5.1 Sprinkler flow

Sprinkler heads changes according to properties of cross-sectional area of orifice, operating pressure and processing property of orifice. Because of head losses, sprinkler head loses pressure as goes from beginning of lateral towards to end of lateral. Therefore decrease in flows occurs (Anonymous, 2010). Difference of maximum 10% in flow and 20% in pressure across lateral line should be allowed to provide a suitable corresponding water distribution. Sprinkler flow is calculated by help of formula below

$$q=3600CA\sqrt{(2gh)} \tag{10}$$

Where.Q:Sprinkler flow m^3/h
C:effective coefficient (0.80-0.95)
A: nozzle cross-section area m^2
g:gravitational acceleration m/s^2
h:operation pressure of sprinkler head. m.

5.2 Precipitation rate

It is defined as water amount given per unit time in irrigation area (Connelan. 2002). It is generally expressed as mm/h. Main factors which affect precipitation rate are sprinkler flow, distance between sprinkler and distance between laterals. The average precipitation rate is calculated with the following equation.

$$Pr=1000*q/S*L \tag{11}$$

Where.
P_r:The average precipitation rate. mm/h
1000: a constant which converts meters to mm.
q:the total flow applied to the area by the sprinklers. m^3/h
S:the spacing between the sprinkler along lateral. m
L: The spacing between rows of sprinkler. m

The flow rate of sprinkler heads automatically changes in case of their making irrigation in different angles. For example, when sprinkler angle decrease from 360° to 180° degree, flow rate increases doubled. Therefore in the system where heads having different angle values are used, the average precipitation rate is calculated by means of the following formula.

$$Pr=360000*q/\phi S*L \tag{12}$$

Where.
Pr: Average precipitation rate of sprinkler. mm/h
360000:a constant related sprinkler's angel.
q: flow rate of sprinkler. m^3/h
ϕ: Working angel of sprinkler. ^{0}

Precipitation rate requires considering soil infiltration rate in order to prevent runoff and deep seepage to be determined.

5.3 Irrigation duration

Irrigation duration refers to required time for each irrigation. This duration is a function of net water application depth, precipitation rate of sprinkler and irrigation efficiency. Irrigation duration is calculated by the following formula

$$Ta=dn/(Pr*Ea) \tag{13}$$

Where.
T_a: Irrigation duration. h.
d_n: net water application depth. mm
P_r: Precipitation rate. mm/h
E_a: Application efficiency. % (80% can be taken for sprinkler)

5.4 Lateral flow

Lateral flow changes according to the number of sprinkler which is planned to be placed on the lateral and their flow rate. Lateral flow which they need to carry increases similarly as number of heads and flow rate are increased. The lateral flow inlet is determined by equation 14.

$$Ql=qs*ns \tag{14}$$

Where.
Ql: lateral flow. l/s
qs: sprinkler flow. l/s
ns: the number of sprinkler on lateral

Sprinkler heads having wetting area in shape of circular, semi-circle and quarter circle on the same lateral are often used depending on geometrical shapes of irrigation area. In case of using heads having different flow rate on a lateral, heads which have the same flow rate are grouped and number of heads are multiplied and the total flow rate of lateral is defined.

5.5 Operation unit

Unit which is constituted from heads making irrigation in irrigation area is called as operating unit. Maximum operating unit is calculated by means of following formula.

$$Nmax=(Tg/Ta)*SA \tag{15}$$

Minimum operating unit is also calculated by means of following formula.

$$Nmin=\Sigma q/Q \tag{16}$$

Where.
q:sprinkler flow m^3/h
Q:system flow m^3/h

N_{max}: maximum number of station
Tg: achievable irrigation duration per day, h/day
Ta: irrigation duration, h
SA: irrigation interval, day.
Operation unit is considered a number between N_{min} and N_{max} in planning step.

5.6 Hydraulic calculation

Two different head loss are occurred in duration of water`s reaching from resource to plant in delivery of water in an irrigation system. One of them is friction head loss. Friction head loss occurs due to friction within pipes and it is related to length, dimension and coefficient of roughness of pipes. Friction losses are calculated by means of formula of Darcy-Weisbach below.

$$hf=\lambda(L/D)(v2/2g) \quad (17)$$

Where.

h_f:friction head loss m
λ:friction coefficient
L: length of line (m)
D:Inner diameter of pipe work (m)
v: velocity of fluid (m/s)
g: acceleration due to gravity (m/s^2)

Second local head losses occurring in system is called as geodetic and changes depending on type of equipment used. Local head losses are calculated by means of formula below.

$$hl: kf*V2/2g \quad (18)$$

Where.
h_l: local head losses, m
k_f: friction coefficient of irrigation equipment
V: velocity of fluid, m/s
g: acceleration due to gravity, m/s^2

5.7 Matching water flow and pressure with pipe size

Flow in pipes is defined as functions of dimension of pipes and velocity of flow. While determining dimension of pipe in irrigation system investment costs can be minimized through choosing the possible smallest dimension of pipe. However keep in mind that reducing dimension of pipe shall increase the velocity as seen in following formula. Increase of velocity means increase of loss of frictions occurring in pipes.

$$Q=A*V \quad (19)$$

Where.
Q:system flow (m^3/h)
A: line cross-section area: m2
V: velocity of flow. m/s

Possible minimum dimension of head should be chosen according to limitations of friction loss which are allowed. While choosing dimension of main pipe it is required not to exceed 15% of pressure of pumper. Pressure difference between starting and ending point in lateral shouldn`t be over 20%. Also total head losses in system shouldn`t exceed half of orifice pressure.

5.8 Total dynamic head of the system and power requirement

Pressure which is necessary for irrigation system is generally carried out through a pump installed at the beginning of system excluding the situations in which adequate elevation is not available between resource and irrigation area. Pump should be chosen at power which provides optimum pressure in the last head in the line which is called as critical line and has head losses at excessive rate in this system. Total dynamic height of pump in a system is calculated by means of following formula;

$$Ht=hs+hh+he+hsuc \tag{20}$$

Where.
H_t: total dynamic head of pump, m
h_s: sprinkler operation pressure, m.
h_h: total head losses, m.
h_e: elevation difference between highest point in irrigated area and pump, m
h_{suc}: suction line height if there is elevation difference between pump and water supply suction line height should be considered.

Also engine power of pump is required to be determined. Pumping Energy which is appropriate for system is determined by means of following formula.

$$Np=Ht*Q/75* \mu 1\mu 2 \tag{21}$$

Where.
N_p:Pump power, HP
H_t: Total head loss, m.
Q:system capacity, l/s
μ1: pump efficieny, %
μ2: driver efficieny, %

Pumps which provide necessary pumping power are included in system by help of catalogues of relevant firms.

6. Conclusion

Irrigation is one of the main factors on plant growth and quality. Irrigation is applied in areas where evapotranspiration is not met by rain especially in semi-arid or arid climate. Pressurized irrigation methods are used generally in landscape irrigation.

The most common method between pressured irrigation methods is sprinkler irrigation method. Sprinkler irrigation method is preferred by reasons such as providing high corresponding water distribution, its use easily in any kind of soil and area where plants are grown, its low labor costs and fertilization proceeding`s being easily applied . Determining system units completely according to requirements in project step provides system performance being in high level. Drip and micro sprinkler irrigation methods should be considered as an alternative method in where sprinkler irrigation system is inadequate or ineffective.

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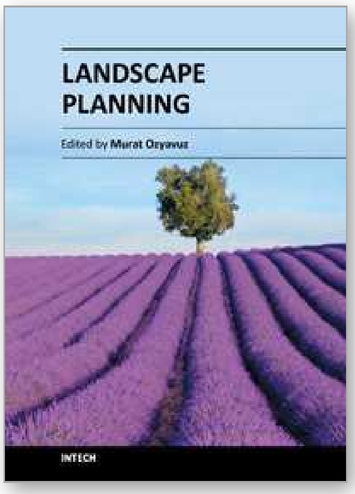

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Landscape architecture is the design of outdoor and public spaces to achieve environmental, socio-behavioral, and/or aesthetic outcomes. It involves the systematic investigation of existing social, ecological, and geological conditions and processes in the landscape, and the design of interventions that will produce the desired outcome. The scope of the profession includes: urban design; site planning; town or urban planning; environmental restoration; parks and recreation planning; visual resource management; green infrastructure planning and provision; and private estate and residence landscape master planning and design - all at varying scales of design, planning and management. This book contains chapters on recent developments in studies of landscape architecture. For this reason I believe the book would be useful to the relevant professional disciplines.