The Use of New Irrigation Systems in Increasing Green Areas and Improve Environment- Case study: Neighborhood 405 in City of Baghdad

Jamal B Motlak¹, Rafah Zuhair Alshaikh² and Mazin Matlak³

¹Professor, PhD, Center of Urban and Regional Planning for Post Graduate Studies, University of Baghdad, Iraq. E-mail: dr.j.motlak@iurp.uobaghdad.edu.iq
²Assistant Lecturer, Center of Urban and Regional Planning for Post Graduate Studies, University of Baghdad, Iraq. E-mail: Rafah.zuher@iurp.uobaghdad.edu.iq
³Agricultural Engineers, Private Sector. E-mail: mazinmatlak@hotmail.com

Abstract. The importance of green areas is to provide a quiet, comfortable, and unpolluted atmosphere. The increase populations of urban cities and the changes of life style is a main problem over a limited water supply and thus overloading the environment. The evolution of modern technologies for saving water is becoming serious to achieve growth in the economy. Sprinkler irrigation is one of the most water efficient irrigation systems. It conserves water, saves money, and reduces problems caused by traditional irrigation ways. Little has been written in Iraq about using underground lawn irrigation system and the proper usage for green areas as to lower cost and system efficiency.

The present research will use the neighborhood 405 in the city of Baghdad, as a case study, to explore the importance of using the new irrigation system, and the common mistakes and practices in designing and installation of these underground irrigation systems. The research find that the irregular distribution of sprinklers and inconsistent spacing, maintenance, which leads to many dry areas.

The mass uses of new and proper underground irrigation system will lead to greener grass, healthier plants, good environment, lower manual labour, and less water usage than the typical watering by hand.

1. Introduction

"Green areas and playgrounds in the city can contribute to raising the health level of the residents, reduce mortality rates, encourage social interaction, and reduce air pollution, noise levels and high temperatures.” [1].

"Green areas purify air and improve its quality. New irrigation and water can settle dust and dirt, turf trap and store carbon that might otherwise contribute to global warming. There are many uses in irrigation and in lawning. New irrigation and lawn agriculture decrease carbon dioxide from the atmosphere hold it in the soil where it eventually becomes organic matter. Lawn generates oxygen, to help along with trees and other green areas. Lawn reduces soil erosion caused by wind and water where root systems lock the soil in place. The present work is aimed at giving a summary as to importance of lawning, the sprinkling systems of irrigation, its methods and the suggestions for the irrigation of the neighborhood 405 in the city of Baghdad."
2. Understanding underground irrigation system
Irrigation system is designed to keep all parts of the lawn and garden evenly moist throughout the growing season. It is important for good plant health that the soil does not become too wet or too dry. Irrigation systems are built in sections, called zones. Each zone is designed to water certain area that is separate from each other, such as turf and gardens. Watering will be done in slow and gentle application that lets the water sink into the soil rather than run off. Some zones can use different timing, due to sloped ground [2].

With underground lawn sprinkler system you will:
- Time reduction: your system will do all the watering for you.
- Reduce Water consumption: a sprinkler system uses less water than by hand.
- Reduce money.
- Be sure: quality, value, and performance.

3. History of irrigation
Mesopotamia was the first to establish an irrigation system, around 4000 BC. “Using complicated system of trenches and ditches aided by animal and human power. The residents of Wadi Al-Rafidain invented the first and most complex irrigation systems to divert the available water for long distances, and lift them to high areas in the city of Babylon. Irrigation is always had a decorative aspect, to create the good look and romantic feel” [3].

4. The Benefits of Lawns
There is a relationship between urban populations, high population densities, environment quality, fast-growing cities that increase all types of pollution, urban growth exacerbate the problem of "climate change and fosters economic development. As income rises, household consumes more energy at home, work, road, and industries" [4]. The benefit of lawn and green areas goes far beyond water waste. Goals should be aimed towards the environmental and personal benefits that lawns bring to life.

"Green areas have many benefits such as” [5]:
- Green areas help stabilize the soil
- Conservation of groundwater.
- Improve the air quality by absorbing carbon dioxide
- Reduce the temperature, as it helps to reduce the temperature from 5 to 7 degrees comparing with built-up areas” [6].
"Lawn supplies residential area enough oxygen, absorbing carbon dioxide, hydrogen fluoride, ozone, and peroxyacetyl nitrate.
- Healthy lawn prevents surface run-off, absorbing rainfall more effectively than an open space without lawn” [7].
- Helps control air pollution (dust and dirt into the atmosphere).
- "The front lawns of eight average houses have the cooling effect of about 70 tons (68 metric tons) of air conditioning, while the average home-size central air has only a 3 to 4 ton capacity (2.7 to 3.9 metric tons).” [8].
- Reduce different types of noise.

For these reasons, lawns have become an important part of urban shape and life.

5. The Underground Lawn Sprinkler Irrigation System
The method of irrigation by sprinklers is very similar to natural rain. Water is pumped through the pipes while Sprinkler heads spread water into the air as small droplets drop onto the lawns. There is a set of requirements in choosing an irrigation system

Some of these factors are:
- Type of suitable sprinklers.
- The area of the garden or area to be planted.
- The nature of the climate in the region includes wind speed and direction, temperatures and humidity.
- Soil quality and water absorption

The above factors are directly related to the type of proper irrigation system and the appropriate sprinklers to maintain green lawns and plants.

6. Types of Underground lawn sprinkler irrigation system

There are many types of sprinklers and irrigation equipments. Each type has a particular specification and space distance, which the beneficiary may need. They would be best used one landscaping project. The main types of lawn sprinkler:

6.1 Solid- set sprinklers

Some types of irrigation devices are in the form of vertical pipes, and the sprinkler is at the top of the pipe. They are designed in triangular or rectangular arrangements to cover the entire field see Figure 1.

![Figure 1. The solid set sprinklers.](image)

The disadvantage of solid- set sprinklers Systems is that they are not safe, piping and actual sprinklers are an obstruction for people and children. Ugly, sticks are like a sore thumb, and destroy beauty (unless it is hidden between shrubs). They have short life expectancy Figure 2.

![Figure 2. The obstruction of solid- set sprinklers for people and children.](image)

6.2 Spray (pop-up) sprinkler

For small areas, Pop-up spray sprinklers are used. Spray sprinklers emit water in a fixed pattern, usually a particular part of a circle or arc. Spray sprinklers have an operating range of 15 to 30 psi pressure and throw water across a radius of 5 to 22 feet (1.5 to 6.7 meter)” [10]. as shown in Figure.3.
6.3 Rotating sprinklers

The type of sprinklers used shall be determined according to the area and shape of the area required. The first goal in the design of green area is to use the type of sprinklers according to the type of plant material to be irrigated such as Lawn, and trees. The second goal is to use the minimum number of sprinklers to cover the required space. It is not recommended to mix different types of sprinklers in one zone. Rotating sprinklers operates for higher pressure as compared with spray sprinklers Figure. 4.

Most rotating operates between 25 to 100 psi pressures. Coverage Rotating sprinklers distance from 20 to 100 feet (6 to 30 meter).

Rotating sprinklers is best than spray sprinklers because of large water flow, and large area covered. It should be noted that the flow demands and gallons of water (g/m) (gallon per minute) for large radius sprinklers are much higher” [10]. Table (1, 2, 3) show the nozzle performance for 5000 series rotor, 8005 series rotor and 15 series spray, respectively.

| Pressure (psi) | Nozzle | Radius (ft/m) | Flow (g/m) | Sqprecip (in/hr) |
|---------------|--------|---------------|------------|-----------------|
| 25            | 3.0    | 36/11.2       | 2.26       | 0.34            |
| 35            | 3.0    | 38/11.2       | 2.71       | 0.36            |
| 45            | 3.0    | 39/12.1       | 3.09       | 0.37            |
Table 2. Nozzle performance for 8005 series rotor.

| Pressure (psi) | Nozzle | Radius (ft/m) | Flow (g/m) | Sqprecip (in/hr) |
|---------------|--------|---------------|------------|-----------------|
| 50            | 22     | 65/20.0       | 20.7       | 0.94            |
| 60            | 22     | 71/21.3       | 23.2       | 0.89            |
| 70            | 22     | 73/22.0       | 25.2       | 0.91            |
| 80            | 22     | 75/22.4       | 27.3       | 0.93            |

Table 3. Nozzle performance for 15 series spray

| Pressure (psi) | Nozzle | Radius (ft/m) | Flow (g/m) | Sqprecip (in/hr) |
|---------------|--------|---------------|------------|-----------------|
| 15            | 180 arc| 11            | 1.31       | 2.08            |
| 20            | 180 arc| 12            | 1.51       | 2.02            |
| 25            | 180 arc| 14            | 1.69       | 1.66            |
| 30            | 180 arc| 15            | 1.85       | 1.58            |

7. How Many Sprinklers One Can Use?

The answer depends on the factors of:
- Gallons + pressure + nozzle
- Gallons means the size of pipe (Poly Pipe)
  1.0 inch = 15 GPM
  1.5 inch = 30 GPM
  2.0 inch = 50 GPM

7.1 Precipitation rate

“The water delivery rate is measured in inches per hour or millimeter per hour at particular sprinkler spacing. It must be needed to know the quantity of water per day will be required to maintain the lawn”. [11].

To calculate the precipitation rate (inch per hour) this formula can be used,

\[ PR = \frac{96.3 \times \text{gpm}}{(S \times L) \text{Tri. or (S x S) Sq. spacing}} \]

96.3 is a constant which incorporates (inches per square foot per hour).

Gpm: is gallon per hour applied to the area by the sprinkler.

\( S \): the spacing between sprinklers.

\( L \): the spacing between rows of sprinklers.

The constant 96.3 is derived by obtaining the depth (in inches) the sprinkled water penetrates per hour. So that, if 1 gal water (231 cubic inch) was applied to 1 square foot (144 square inch) the depth of water penetration will be:

\[ \frac{231}{144} = 1.604 \text{ inch/minute} \]

\[ = 1.604 \times 60 \text{ (minutes)} \]
\( = 96.3 \text{ inch/hour} \)

7.2 **Pressure loss.** [12].

“Loss of pressure occurs in the pipes of the irrigation system because of several factors are:

- Gravity
- Viscosity
- Roughness of pipes lining

7.2.1 **Velocity**

“Water flow rate (velocity the speed of water) is measured in (feet per second). Velocity cannot exceed 5 Feet per second”. [12].

7.2.2 **Hydraulics**

Hydraulics is defined as the study of water behavior. Properly designed piping, can greatly reduce maintenance problems over the life of an irrigation system. Controlling the water flow velocity reduces wear on the system components and lengthens service life. Poor hydraulic design results in poor performance of the irrigation system, leading to stressed landscaping material, or even broken pipes and flood damage. The lack of design can cost more money, and waste water, and increase risks. [11].

7.2.3 **Water Conservation**

Using an automatic lawn irrigation system may seem wasteful, but in reality it wastes less water than hand or flood watering. Water becomes the most expensive commodity in our life. Saving water is the most responsible work of individuals, communities, and governments.

Oscillating sprinklers loses almost as much water to the atmosphere as is finally applied to the lawn, due to evaporation before reaching the ground. Not even mentioning the labour cost.

With hand watering, much of the water is lost due to the improper timing of turning on and off. Hand watering can waste almost 50 percent of the water applied, compared with a well-designed irrigation system. The automatic underground irrigation system provide less labour by cutting down of dragging the hose. Provide the right amount of water at the best possible time. The applied water if used efficiently will minimize waste. The result is the conservation of water resources and the enhancement of lawn health.

Overwatering and water runoff are major sources of water waste, beside water shortage in the main rivers. With a well-designed underground irrigation system, you can be sure you do not add to that problem. In addition, as water rates rise, every drop you save is money in the pocket, [11].

8. **Coverage and Spacing Sprinkler**

It is necessary to regulate the distances between sprinklers to achieve homogeneity in irrigated areas, and not to show dry areas.

The proper placement of sprinkler requires that each sprinkler should spray to the head and equal spacing between heads to permits uniform water distribution. This means designing equal spacing between sprinklers, ensuring no dead spaces [13] Figure. 5 show good head-to-head coverage.

![Figure 5. The good coverage water](image-url)
Figure 6 is an example of bad distribution of sprinklers so the coverage area is not uniform which causes dry area (the part in red) [14].

![Figure 6. The bad coverage water.](image)

The regular distribution of sprinklers achieves a uniform distribution of water over the specified area. Figure 7 [15]

![Figure 7. Showing head to head spacing.](image)

There are two basic types of sprinkler spacing patterns can be distinguished, namely, square, rectangular and triangular geometric shape Figure. 8. No clear advantages between them but that it depends on the sprinkler water distribution pattern [13].

![Figure 8. Basic types of sprinkler spacing patterns.](image)
The square of sprinklers distribution is used for the case of square areas. In the case of irregular areas, the triangular shape is used, and in cases where circular sprinklers are not required.

9. Case Study
This research will use the neighborhood of 405 in the city of Baghdad Figure 9, as a case study, to explore the importance of using the new irrigation system, and the common mistakes and practices in designing and installation of underground irrigation systems.

![Figure 9. The case study (Neighborhood of 405 in the city of Baghdad)](image)

9.1 Design and installation errors (spacing and coverage)
Figure 10 illustrate the actual layout of present case which shows the irregular distribution of sprinklers and inconsistent spacing, which leads to many dry areas.

![Figure 10. The actual layout and the inconsistent spacing of the sprinklers.](image)
Figure 11 show the dry areas caused by the irregular distribution of the sprinklers and the random spacing among them.

![Figure 11. Show the dry areas of case study.](image)

The Figure 12 shows the proposed design of sprinklers distribution for getting green land without any dry areas.

![Figure 12. The proper layout of the sprinklers.](image)

The improper additions to the area, like trees and hedges which were planted near the sprinklers installation, blocks the water spray which leads to big and many dry areas, as well as the over growth of trees and hedges as shown in Figure 13 and Figure 14.
Figure 3. Show the sprinkler which is placed near the trees and hedges.

Figure 4. Show the sprinkler which is installed close to the hedge of garden.

It was noticed that most of the sprinklers were not uprightly installed and the other sprinklers were placed too high from the ground level. Therefore, the lawn were not completely covered by the sprinklers spray, which leads to the presence of dry areas in the garden, as shown in Figure.15.
Figure 15. show the difference in ground levels, the lawn, the walking path and many holes which are hazard to pedestrians and public are all over the area.

10. Common Mistakes and Wrong Practices in Designing and Installations of Underground Sprinklers System in Neighbourhood 405

1. Uneven or inconsistent spacing between sprinklers. (Irregular distribution/too far spacing)
2. The use of wrong type of sprinklers for the site
3. Mixing different types of sprinklers in same zone
4. Overloading the zone
5. Poor installation (ex. upright of sprinklers)

Work site requires complete effort, control, and communication between site manager and all other trades, contractors, and subcontractors to produce a successful project to give the public long years of service.

It is very important to set a proper design and layout for all types of constructions.
- Underground sprinklers layout
- Landscape layout (shrubs, trees, and hedges)
- Walkways and Paths
- Other furniture (benches, waste containers, light posts, children swings, etc)
- Site manager or local organization must have complete as-built drawings from all contractors for future reference and any additions or changes

Finally, the on-going maintenance by knowledgeable personal (mowing, proper replacement of faulty parts, and tree trimming, etc.).

11. Recommendation
1. The need to convert open space into green areas, which is important in improving the environment and creating play areas and gathering of residents.
2. The use of modern irrigation methods (sprinklers) because it saves time, water and money.
3. Use the correct design methods in the distribution of sprinklers to achieve quality and efficiency of performance.
4. Emphasize the maintenance of sprinklers for the purpose of achieving sustainability in the work of irrigation systems and the achievement of green areas beautiful and durable.
References

[1] Kabisch N and Others 2017 Nature based Solutions to Climate Change Adaptation in Urban Areas (open access publication) p 2.

[2] Ossa J and Rafael S 2010 Turf and Landscape Irrigation Best Management Practices (the Water Management Committee of the Irrigation Association California) p 3-4.

[3] Marilyn Rogers 2007 Scotts Sprinklers & Watering Systems (Meredith Books)

[4] Matthew E Kahn 2006 Green Cities, (Brookings Institution Press Washington D.C.) P 2

[5] Gramckow J 1968 Athletic field quality studies. Beard and other scientists report. Cal-Turf Inc., Camarillo, CA.

[6] James B Beard and Robert L Green 1994 The Role of Turf grasses in Environmental Protection and Their Benefits to Humans (J Environ Qual Texas A&M University) p 5.

[7] Arthur Bruneau S C Hodges L T Lucas 2001 Water Quality and Professional Lawn Care (North Carolina State University) p 1.

[8] Nowak D J Crane D E Stevens J C 2006 Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening (Elsevier GmbH) P 4.

[9] Ed N A 2009 Irrigation and Drainage Engineering: Principles, Design, and Practices (Minna Nigeria Jos University Press) P.

[10] Martin D L and Others 2007 Design and Operation of Sprinkler Systems (University of Nebraska, Lincoln) p 560.

[11] Zakari M D 2012 Design, Construction and Installation of Sprinkler Irrigation System Journal of Engineering and Technology (JET) 7 109-117.

[12] Anonymous 2009 Designing a New Irrigation System (Publication: http://www. irrigationtutorials.com)

[13] Yan H J Bai G He J Q Li YJ 2010 Model of droplet dynamics and evaporation for sprinkler irrigation Bio systems Engineering 106(4) 440-447.

[14] Li J 1996 Sprinkler rotation non uniformity and water distribution China Institute of Water Resources and Hydropower Research 39(6) 2027-2031.

[15] Ascough G W and Kiker G A 2002 The effect of irrigation uniformity on irrigation water requirements Water SA 28(2) 235-241.