Irrigation Network Requirements for Watering Urban Green Space in Semiarid Region

Hadja Guedaouria¹,a, Mebarka Daoudi¹,b*, Youcef Benmoussa¹,c and Abdelhak Maazouzi²,d

¹LPDS Laboratory of Semiconductor Devices physics, University of Bechar, P.O. Box 417, Bechar (08000), Algeria
²LCSE Laboratory of Chemistry and Environmental Sciences, University of Bechar, P.O. Box 417, Bechar (08000), Algeria

*a hadja.guedaoria@univ-bechar.dz, *daoudi.mebarka@univ-bechar.dz; 
³youcefbenkadi@gmail.com; ⁴maazouzi.abdelhak@univ-bechar.dz

Abstract. The presence of green spaces in cities is a vital thing as it contributes to raising the quality of urban life, increasing environmental diversity, improving the social aspect of the individual and society, increasing economic income and adding an aesthetic aspect to cities. In this work, a powerful design steps of drip and sprinkler irrigation networks is presented to watering an area about 300m² of green space at semiarid region in Algeria. The first step consists of the hydraulic sizing of drip irrigation system for different dripper flow (from 4 l/h to 23 l/h), the next step concerned the sprinkler irrigation using two models of sprinkler the first one is IPN-5-F characterized by radius 1.5m, flow 0.09 m³/h and arc 360° and the second one is IPN-12H characterized by radius 3m. The dripper with flow 15l/h and the sprinkler 12’ are the suitable in terms of the irrigation hours and the energy requirement to run the solar pump. The values of irrigation frequency in drip and sprinkler irrigation are closed from 1 for drip to two days for sprinkler, in other hand the flow rate in drip irrigation network is negligible comparing with sprinkler irrigation network. In these conditions, it is useful to install only one pump with the greater debit for the two networks of irrigation using pressure reducer in manifold pipes of drip irrigation network.

1. Introduction
The presence of green spaces in public places allows to improve the quality of air, water, and land by absorbing pollutants, as it works to make the air temperature at the permissible levels, providing shade and stabilizing the soil, in addition to reducing harmful carbon dioxide emissions [1]. Green spaces have an important role in reducing the harmful consequences of the rapid rate of urbanization. They make the balanced distribution between buildings, transport, and infrastructure. To make the development of our civilization sustainable and cause less harm to our environment, using a new source of substitute clean energy as solar energy is the important. Algeria is considered as the largest solar potential of the entire Mediterranean basin, by 169000TWh/year for solar thermal and 13.9TWh/year solar photovoltaic. Where the duration of sunshine in the Algerian Sahara is about 3500h/year, which is always greater than an 8h/day and can reach up to 12h/day during the summer [2-3]. In this context, the aim of this paper is designing a smart irrigation system of urban green spaces for a semiarid region in Algeria specifically Bechar southern region using solar energy to feed the
Two irrigation schemes were selected for this study: drip and sprinkler irrigation networks, general concepts that apply to design and operation of these systems are in details in the sections below. The design of the smart irrigation system considers the selection of the irrigation method, the crop, the soil, and the shape of the green space. The following points are the most important criteria to be considered:

- Excessive pressure allows the water to be dispersed into a fine mist, which facilitates the process of evaporation and imbalance in distribution. At the same time, weak pressure leads to water flow, poor distribution, and loss of large quantities of it.
- Effects of temperature and wind on sprinkler irrigation in terms of evaporation and distribution.
- It is recommended to use flat areas or re-level them with a slight slope of 2%.

2. Methodology

It is essential to confirm the source and quantum of water available before designing of any irrigation system taking into consideration local conditions, including elevation differences, local climate data, soil type and crop details (type, growth stage and pacing), after collection of basic information, establish the following steps [4,5]:

- First, Estimate the peak water requirement.
- Select the type of irrigation system drip or and sprinkler system.
- Calculate the irrigation frequency and operational time.
- Size the pipes (supply line, mainline, manifold and laterals).
- Calculate the total friction losses.
- Calculate the total dynamic head.
- Finally, calculate the pumping required power.

The schema presented in figure 1 illustrates a simple design of irrigation system intended for watering a green space.

![Design of irrigation system for green space.](image)

**Figure 1.** Design of irrigation system for green space.

For more details the following references [6-13] provide an overview of the model used to estimate and calculate crop water needed to schedule daily and weekly irrigation and the hydraulic sizing for the two types of irrigation systems drip and sprinkler systems respectively presented in the figure 1.
2.1. Pipes sizing
To select pipes, it is important at first to calculate allowable pressure variation that will give emission uniformity reasonably close to the desired value, after compute the friction losses in supply line, mainline, manifold and laterals for more details check reference [5].

2.2. Total dynamic head
Total Dynamic head (TDH) is the total head required to provide the required pressure at the end of the dripper or sprinkler as shown in figure 2.

\[
TDH = De + Ff. (Sl + Fs + Fc + Fml + Fmn + Fl + Op)
\]

De: The difference in elevation between the water level and the highest point on the land.
Ff: Friction losses in fittings.
Sl: Suction lifts.
Fs: Friction losses in the supply line.
Fc: Friction losses in the control head.
Fml: Friction losses in mainline.
Fmn: Friction losses in manifold.
Fl: Friction losses in the laterals or driplines.
Op: The drippers or sprinkler’s operating pressure.

2.3. Pumping power requirement
Power requirement \( Pr \) is the power needed to operate the pump, it can be calculate using the relationship below [8]:

\[
Pr = \frac{Q \cdot TDH}{360 \cdot e}
\]

Q: Flow in main line.
e: Pump efficiency.
3. Study area: application example
The study area is a green space divided into two areas comprising palm trees in the middle of the area and in the laterals the grass and flowers shrubbery plants where they have similar water requirement as shown in figure 1. This green space is in the University of Bechar located in Bechar city semiarid region, in the south of Algeria. It covers about 300 square meters and forms a valuable natural space for students. This green space has sandy loam soil type and is divided on three parts, the middle part watered by drip irrigation system where contain ten palm trees spaced by 3m. In the two rest parts there are grass and flowers watered by sprinkler irrigation system. In drip irrigation network, each palm has 2 emitters spacing by 1.5m where the wetted area by one emitter is 4m², whish presented 60% of wetted area [6].

4. Results and discussion
First, the climatic data collection for Bechar-Algeria semiarid region during the corn period, which takes place in the middle of July as ; the minimum and maximum temperature ($T_{\text{min}} = 25^\circ$ and $T_{\text{max}} = 40^\circ$), the day solar radiation (6944.4W/m²/day), the sunshine hours (10.4 hours), the humidity (33%) and the wind speed (156Km/j) needed for running the calculation, after the collection of the principal data for hydraulic sizing is necessary [2]. Once suitable parameter values have been estimated for each type of crops and area, the irrigation systems characteristics can easily determine. For the drip irrigation network, two emitters for each palm with 1.5m emitter spacing is determined. The area wetted by one emitter is about 4m², with 60% of wetted area. To choose the best dripper flow, it is important to make comparison between different dripper low. The results of sizing for variation of dripper flow from 4 l/h to 23 l/h present a decreasing of the irrigation hours, and the pipes friction loss of laterals and manifolds has risen in reason of the flow and diameters of pipes. The total dynamic head depend on friction loss thus it increases, this led to rise the energy requirement for running the solar pump from 15W to 88W. The irrigation frequency remained constant in all different drippers because it depends on the crop water requirement. In terms of operation times and power requirement, the dripper of 15l/h for pump debit about 0.6m³/h is the suitable choice. In sprinkler irrigation network, two models of sprinkler have used, the first one is IPN-5-F characterized by radius 1.5m, flow 0.09 m³/h and arc 360° and the second one is IPN-12H characterized by radius 3m, flow 0.11m³/h and arc 180° [11-12]. In the first hand, the sprinkler IPN-12H is the suitable choice comparing with the sprinkler IPN-5F in terms of number of sprinklers, pump flow and power requirement. For optimum design we put in corners sprinklers IPN-12Q with an arc 90°, for more details about these types of sprinklers see the reference [11]. For the reason of the sprinkler head spacing percentage which is around 60% (for desert region), the sprinkler spacing is about 4.2m [12]. In the second hand, the irrigation frequency values range from 1 to 2 days for the two types of irrigation systems drippers and sprinklers, respectively. in other hand, the pump debit in drip irrigation system (0.6 m³/h) is negligible comparing with pump debit in sprinkler irrigation system (1.5 m³/h), furthermore the irrigation hours in the two networks are closed 2 hours for drip irrigation and 1.5 hours in sprinkler irrigation. For all these reasons, it is suitable to install only one pump characteristics by the greater debit for the two networks and for the drip irrigation system it is necessary to use pressure reducer in manifold pipes. In addition, there are some cases which could affect and interpret the progress of power requirement to running the pump and total dynamic head. In below, three cases are studied:
- **Case 1**: variation of distance between the water source and the green space from 10 to 100m.
- **Case 2**: variation of difference in elevation between the water level and the highest point on the land from 1 to, 10m.
- **Case 3**: variation of suction lift from 1 to 5m.

The power requirement increases relatively from 126W to 200W because the total dynamic head boost slightly from 18m to 27m. Whatever the long of supply line rise, the total friction losses do not exceed the allowable pressure variation which equals 1.5m in our case, this achieved by changing of
pipes section. For an ideal irrigation system, the slope is 2% or less, if it is greater than this value it caused changing in pressure which need more power to maintaining the required flow rate. In this condition it is strongly recommended to use pressure compensated drippers [14]. In the third case, the faintly rise in $TDH$ and $Pr$ caused by little change in the suction lift, which does not exceed 5$m$ for surface pump. As a conclusion, it is important to study the performance of seasonal crop water need ($ETc, I_f$ and $T$) at peak demand for the two types of irrigation networks. The succession of the seasons rises $ETc$ by the way the decreasing of $I_f$, and increasing of $T$ where the minimum and the maximum values reached at corn period (period of summer) after that they recede in autumn. In addition, the irrigation frequency takes a minimum value in winter, then it rises again in summer. In summer, the temperature and evaporation rate rise, consequently, crop water need increases which requires more time for irrigation and less irrigation frequency. As mentioned before, both drip and sprinkler irrigation networks are combined in one system of irrigation, and because of their irrigation duration values which is incompatible it is recommended to use a smart irrigation system. This study will be published later.

5. Conclusion
The design of irrigation systems is a very important topic to improve the application, efficiency, and economic return of irrigation in the production process. The design should be based on the standards that are mainly related to knowledge of irrigation, hydraulic, economic, energy, and environmental aspects. The main aim of this study is to provide the population, as well as the persons responsible for the irrigation of public green spaces, with the knowledge and tools necessary to achieve the efficient use of water for outdoor irrigation. An irrigation system is a network of permanent pipes connected to emitters and sprinklers designed and installed for the water of a specific natural area. Emitters and sprinklers are tools mounted on a tube operated under pressure to drain water in the form of a drip and nozzle, respectively. An efficient irrigation system is one that is designed and installed to reduce water production capacity.

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