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Draft sprinkler irrigation system design development

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Abstract. This article shows the analysis of the parameters of a sprinkler irrigation system following different natural conditions (climate, soil, and hydrogeological) and their analysis in the implementation of the hydraulic calculation and design. According to the majority of literature, several calculations are made for the pressure and discharge during sprinkler irrigation. In the system under analysis, calculations are made on the irrigation processes of pipes and their outflow. It uses Google Earth and AutoCAD. In the hydraulic calculation of the system parameters, it was determined that the area's natural conditions are important and that changes and additions should be made to the calculations.

1 Introduction

Efficient water use is important in assessing climate change and its impact on Uzbekistan, which has become one of the most pressing issues today. It is also important to prevent the events and processes that are increasing daily, leading to the depletion of the Ozone layer, the Greenhouse effect, and the increase of Carbon dioxide. If the issue is focused on the efficient use of water, given the growing population and the fact that the main water is spent on irrigation, the issue of adapting water-saving irrigation technologies to the territory of Uzbekistan arises. Because this process is very complex and important. This article examines the impact of the region's natural conditions on the design work required for the Irrigation System.

Flow dynamics in a sprinkler system is a complex process. Many scientists have researched this process. In particular, Derrel L. Martin (University of Nebraska, Lincoln, Nebraska), Dele F. Xeermann (USDA-ARS, Fort Collins, Colorado), Mark Madison (CH2M Hill, Portland, Oregon) -2017, "Hydraulics of sprinklers and micro irrigation systems", Keller J., and R.D. Bliesner. 1990, "Sprinkler and Trickle Irrigation," N.Y. Van Nostrand, D.S. Kinsaid, and D.F. Xeermann 1970, "Pressure distributions on a center-pivot sprinkler irrigation system," S.P. Liou 1998, Limitations and proper use of the Hazen-Williams Equation, scientists have conducted their experiments on the design of the Sprinkler Irrigation System. Sprinkler irrigation is one of the most common types of

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Rainfall irrigation systems. In many areas, there is a lack of water and energy to spend on irrigation. Martin Benito also wrote in a 1992 article that the Sprinkler irrigation system requires less energy, saves water, and plays an important role in water efficiency. These experiments we have seen above were carried out following a specific region, i.e., natural conditions, and they are suitable only for these areas. The impact of natural conditions on the hydraulic calculation of the Sprinkler irrigation system plays a big role. It is clear from a few experiments that natural conditions' effect is very important, especially in the Sprinkler irrigation system. The Sprinkler system is very tough to learn. There are a few laws we should learn, especially at a time when water is scarce.[2,14,20]

In this article, solving the above problems, a sequence is developed for implementing the sprinkler irrigation system project. For this, the parameters affecting the sprinkler irrigation system are considered. We will study the cases related to the hydraulic calculation and laws of movement of the water coming out of the Sprinkler. We also consider the natural conditions that affect sprinkler irrigation system design.

1.2 Problem statement

This article considers the main methods of adapting its design to the natural conditions of Uzbekistan (climate, soil, and hydrogeological) are considered on the basis of experiments. Typically, the water supply for irrigation reaches the pipes and crops from the canal. Before reaching the pipe, the water is cooled and filtered, depending on the source and irrigation system. In the pipeline, the water rises under pressure and reaches the sprinklers, and at great speed, the water is distributed to the crop and the soil. Sprinklers are installed at different depths with different taps and according to different pressures and wind speeds. The water that reaches the network is used along the sprinklers for the crop above the ground. This paper analyzes the flow movement in pipes in Sprinkler Irrigation and the associated hydraulic elements by adapting them to local conditions.

The natural conditions of the field will be studied to develop hydraulic calculations suitable for the territory of Uzbekistan. Google Earth and AutoCAD are used to study the altitude, area, and location of the area above sea level. A spatial image of the sown area is taken, and the boundary and slope are determined. Data from the region's climate and soil parameters will also be obtained from the Hydrometeorology Centre. The impact of climate, soil, and groundwater on hydraulic accounting is assessed. The required pressure and discharge are calculated in the sprinkler system until the moving water reaches the crop from the source.

2 Hydraulic part of the pipe

A pressurized irrigation system is divided into several directions in which water is transported from the source to the pipes along the entire flow. The flow in the main routes is divided into trunk canals and several sections. The water flow directed to the plots fills the soil surface or Sprinkler. In these directions, the loss of pressure occurs. The main energy loss occurs in the surface layer of the pipe in a constant flow type.
More attention is paid to their surface area in calculating friction in solids. On the other hand, water has a high viscosity, in which particles in the water also participate in friction, and a complex process occurs. The head loss is divided into long-lost pressure and local resistance. The total head loss is calculated by the sum of the head loss at length and local resistance. The Darcy-Weisbach formula is used to calculate the longitudinal loss in pipes. Darcy Weisbach's equation has the following form [1, 7, 14, 19]:

$$h_l = \lambda \frac{L}{D}\frac{\vartheta^2}{2g} = \left(\frac{8\lambda}{\pi^2 g}\right)\frac{LQ^2}{D^5} \quad (1)$$

where, h_l is head loss in length, m; λ is hydraulic resistance coefficient; D is Internal diameter of pipe, mm; L is length of pipe, m; ϑ is velocity of water in the pipe, m/s; g is acceleration of free fall, m/s^2

The hydraulic resistance coefficient λ is also referred to as the friction driving factor, which is mainly the coefficient related to the roughness e/D and the Reynolds Re number. The absolute roughness is given by the length of the roughness "e" depending on the pipe material. The resistance coefficient is a measurable quantity and is determined in the form of an empirical equation [2, 3, 6, 8]:

$$\frac{1}{\sqrt{\lambda}} = 1.14 - 2\log\left(\frac{e}{D} + \frac{9.35}{Re\sqrt{\lambda}}\right) \quad (2)$$

$e'' = \frac{e}{D}$ is internal absolute roughness of the pipe, mm.

The average velocity of the flow is said to be the ratio of the flow rate of the water flow to the moving cutting surface. This velocity, in turn, affects the flow regime, and the Reynolds number for the pipes is calculated as follows [1, 2, 4, 7]:

$$Re = 1.273 \cdot 10^6 \frac{Q}{D} = 1.273 \cdot 10^6 \frac{\vartheta\omega}{D} \quad (3)$$

Typically, the Reynolds number ranges from 300,000 to 700,000 in the moving part of Irrigation. The number of Reynolds decreases as the water reaches the Sprinkler. The coefficient of resistance is determined according to formula (2) depending on the pipe's roughness and inside diameter. Table 1.1 shows the friction and roughness coefficient values according to the pipe material.

Table 1. The amount of roughness to calculate the Darcy-Weisbach friction factor

Material	Roughness (n)
Aluminum	0.10-0.30
Asbestos cement	0.0015-0.0025
Processed iron	0.03-0.09
Concrete	0.20-3.00
Corrugated metal	30.0-60.0
Plastic, polyethylene	0.0015-0.0025

As sprinkler irrigation's speed and water consumption increase, so does the number of Reynolds in proportion to the diameters. We can calculate the friction coefficient and the head loss along the length according to the Reynolds number, pipe material, and diameter. This is a necessary expense [12, 16, 18].

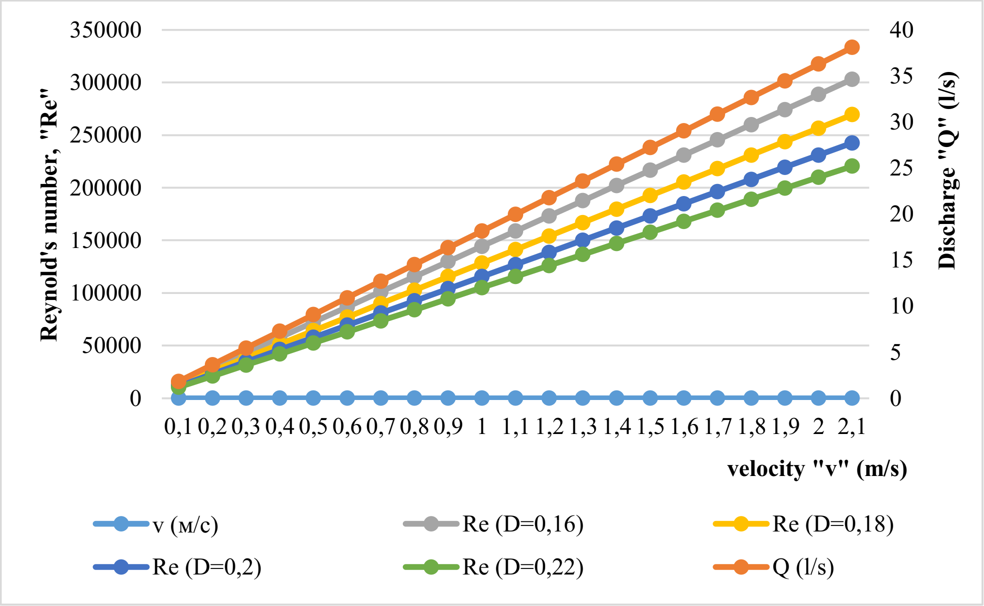
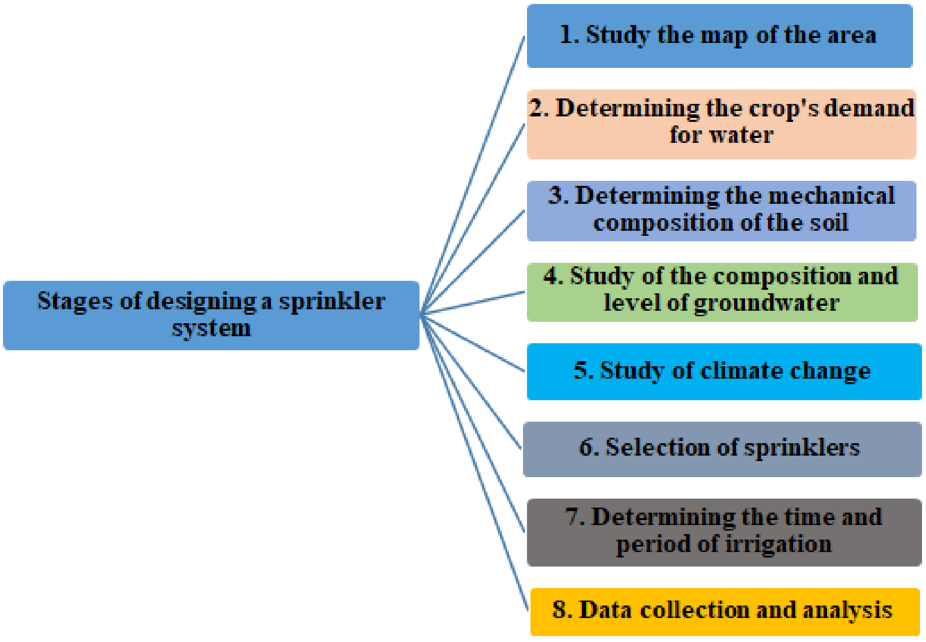


Fig. 1. Graph of Reynolds number for different pipe diameters according to formula 3, water consumption, and velocity

3 Results and Discussion

We will now consider the design and assessment of the impact of natural conditions on the hydraulic account of the parameters of the sprinkler system in several stages:



Study the map of the area. Using the functions of Google Earth and AutoCAD, the area map is studied in terms of altitude. To do this, the area is searched, and marks are made according to its slope. This image is then transferred to AutoCAD, and the field parameters are set according to the scale [Figure 2].

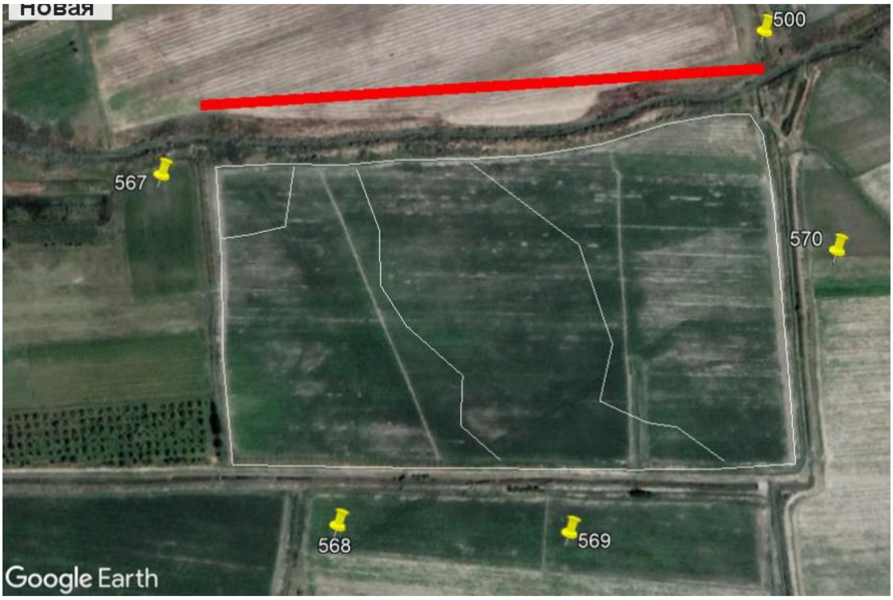


Fig 2. Spatial image of 8 hectares in the Tashkent region of the Republic of Uzbekistan from the program "Google Earth"

Fig 3. Divide the area into sections in AutoCAD

Crop demand for water. The required amount of water is available for each crop, the value of which is calculated depending on several parameters. The water demand of crops varies according to the growth phase. This value increases with increasing temperature and decreasing relative humidity. Daily, decade and monthly amounts of water are taken for each crop type. This value increases with the growth phase of the crop.

Determining the mechanical composition of the soil. Soil conditions are one of the key factors in calculating the required amount of discharge. To do this, soil samples are taken from several field parts, and the composition is studied. According to it, the filtration coefficient is obtained [Tables 2]. Discharge is calculated according to the obtained filtration coefficient.

Table 2. Filtration coefficient of soils

Soil	Permeability in m/s	Coefficient of filtration
Coarse grain gravel	0.1 to 0.005	10^{-1} to $5{\cdot}10^{-3}$
Fine through medium grain gravel	0.03 to 0.0005	$3{\cdot}10^{-2}$ to $5{\cdot}10^{-4}$
Sand gravel	0.01 to 0.0001	10^{-2} to 10^{-4}
Coarse grain sand	0.004 to 0.0001	$4{\cdot}10^{-3}$ to 10^{-4}
Medium grain sand	0.001 to 0.00006	10^{-3} to $6{\cdot}10^{-5}$
Fine grain sand	0.0004 to 0.000006	$4{\cdot}10^{-4}$ to $6{\cdot}10^{-6}$
Clay sand, sandy clay	0.000075 to 0.00000005	$7.5{\cdot}10^{-5}$ to $5{\cdot}10^{-8}$
Clay	0.000005 to 0.0000000001	$5{\cdot}10^{-6}$ to 10^{-10}
Argillaceous clay	0.000004 to 0.0000000001	$4{\cdot}10^{-6}$ to 10^{-10}
Clayey loam	0.00000001 to 0.0000000001	10^{-8} to 10^{-10}

In Uzbekistan, the soil layer is divided into two groups according to their geographical location. The first group is a low-lying lowland with a dry climate, which makes up 71.7% of the country's total area, and the second group is a humid, foothill region with 28.3%. It belongs to the Chirchik-Akhangaran district and has a fertile layer that does not require reclamation measures. This area includes gray soils, meadows, and marsh meadow soils [5, 9, 11, 15].

Study of the composition and level of groundwater. Groundwater composition is one of the important factors. A sampling of this composition and mineralization are studied. If its composition meets irrigation water requirements, this parameter will not harm the crop area and the crop. Otherwise, the level is required to return to normal.

Table 3. Groundwater mineralization

Name	Total amount of solutes "X" (g/l)
Desalinate	$X < 1$
Slightly salty	$1 < X < 10$
Middle salty	$10 < X < 50$
Salty	$X > 50$

Freshwater is considered suitable for irrigation according to the total amount of dissolved substances in groundwater [Table 4]. There is no need to control the groundwater level. On the contrary, it is useful for the crop. If the mineralization of groundwater has

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reached the level of saline and wetlands, it is necessary to reduce its level and reduce damage to crops and soil. It is recommended that groundwater levels with such composition be located at a depth of 2 m or more.

Study of climate change. The study of the region's climate is a necessary factor for the application of water-saving technologies. Climatic parameters such as wind, sun, and humidity are very important, especially when performing a hydraulic calculation of a sprinkler system. The climate is the most important of the external factors that affect it when it rains every drop in the form of artificial rain. If we assume that the discharge of the average Sprinkler is 0.5-0.7 l / s, the speed will vary according to the diameter of the sprinkler system, and the wind will not be affected by this speed. Meteorological data are important in assessing the impact of wind, humidity, and the Sun on a sprinkler and the distribution of irrigation time and period. This information is obtained from the UzHydrometeorology Center. The impact of irrigation on the region's perennial climate indicators will be studied.

Selection of sprinklers. Sprinklers are divided into several types according to discharge and time [Fig 1]. Water consumption is divided into several types according to row spacing and other parameters. The Sprinkler type is selected according to the above parameters.

Fig 4. Types of sprinklers according to parameters

Determining the time and period of irrigation. The crop, soil type, this time, and period, which is calculated based on the natural conditions of the place, is an important factor in determining irrigation. In the distribution of irrigation water, when and at what time it is possible to irrigate the crop is concluded based on the crop's water demand, soil, and climate.

Data collection and analysis. Summarizing and analyzing the above parameters is the final step for the hydraulic part of this system.

4 Conclusion

In conclusion, through the problem presented in the article and the project sequence given to it, we can see the required parameter analysis and proper design system for the Sprinkler irrigation system. By performing these analyses, it is possible to increase water use efficiency, save water in water-scarce areas, and deliver it to crops. In addition to the importance of the area's natural conditions due to the hydraulic parameters of the irrigation system, this effect also plays an important role in the efficient use of water. To properly use, conserve and avoid wasting water used for irrigation in agriculture, it is necessary to develop a methodology for adapting existing technologies to the conditions of Uzbekistan. When climate change and water shortages occur, everyone must use water efficiently and economically before there are difficulties and shortages in delivering water to the population. In studying the parameters affecting the hydraulic calculation of the system and assessing this effect, the changes in discharge in the above formulas and graphs are related to the relationship between velocity and Reynolds number, thereby hydraulic resistance and losses. The irrigation system will be expanded throughout Uzbekistan, thus increasing yields and efficient water use in the regions. In summary, in the article, the change in the parameters in the Sprinkler irrigation system in the performance of hydraulic calculations, i.e., speed varies from 0.1 m/s to 2 m/s, when the inner diameters of the pipe are 0.16,0.18,0.2 m Reynolds and water consumption changes, and graphs were analyzed. At the same time, an 8-step design sequence was created for the Sprinkler irrigation system.

References

1. Arifjanov A., Atakulov D., Akhmedov I., and Hoshimov A.. Modern technologies in the study of processes in channels. In IOP Conference Series: Earth and Environmental Science, 1112(1), (2022)
2. Arifjanov A., Otaxonov M., and Abdulkhaev Z. Model of groundwater level control using horizontal drainage. Irrigation and Melioration, **4**, pp.21-26. (2021)
3. Peter Waller, Muluneh Yitayew. Irrigation and Drainage Engineering. Springer International Publishing Switzerland (2016).
4. Arifjanov A., Kaletova T., Abduraimova D., Samiev L., and Jalilova. Evaluation of the hydraulic efficiency of the sprinkler irrigation system. In IOP Conference Series: Earth and Environmental Science, **1112**(1) (2022)
5. Sh. Rakhmatullaev, Frédéric Huneau , J. Kazbekov4 , H. Celle-Jeanton, M. Motelica-Heino , P. Le Coustumer, J. Jumanov: "Groundwater resources of Uzbekistan: an environmental and operation overview" Open Geosciences January 2012
6. J. B. Sapaev, A. Arifjanov, M. M. Khudayarov. Smart technologies for determination of water consumption in irrigation systems. AIP Conference Proceedings **2432**, (2022); https://doi.org/10.1063/5.0090930
7. Abduraimova D., Atakulov D., Ibragimova Z., and Apakhodjaeva T. November). Evaluation of erosion and accumulative process with using Geoinformation systems in water resource management. In 2019 International Conference on Information Science and Communications Technologies (ICISCT), pp. 1-3. (2019)
8. Rakhimov K., Ahmedkhodjaeva, Xoshimov S. Theoretical bases of hydraulic mixture in round cylindrical pipelines. In IOP Conference Series: Earth and Environmental Science, **614** (1), (2020) doi: 10.1088/1755-1315/614/1/012095
9. Jurík Ľ., Zeleňáková M., Kaletová T., Arifjanov A. Small water reservoirs: sources of water for irrigation. Handbook of Environmental Chemistry, **69**, pp. 115-131. (2019) doi: 10.1007/698_2018_301
10. Arifjanov A.M., Akmalov S.B., Samiev L.N. Extraction of urban construction development with using Landsat satellite images and geoinformation systems. Journal of Water and Land Development. **48** (I–III) p. 65–69 (2021) doi 10.24425/jwld.2021.136147.
11. Arifjanov A.M., Apakxojaeva T.U., and Huska D. Sediment movement mode in rivers of Uzbekistan - Environmental Aspects. Acta horticulturae et regiotecturae, **21**(1), pp.10-12 (2018) https://doi.org/10.2478/ahr-2018-0003
12. Paluanov D.T., Mamatkulov D.A., Gadaev S.K., Saidov F.S. Experimental research on the determination of the filtration characteristic on the base of a low-pressure hydraulic engineering constructions on complex multi-layer ground. In IOP Conference Series: Earth and Environmental Science (AEGIS), **868** (2021)

13. Khamraev Sh.R., Dukhovny V.A., Kadyrov A.A. and Sokolov V.I. Water resources management in Uzbekistan. Global Water Partnership of Central Asia and Caucasus. (2011)
14. Kholmatjanov B.M., Petrov Y.V., Khujanazarov T., Sulaymonova N.N., Abdikulov, F.I., and Tanaka K. Analysis of Temperature Change in Uzbekistan and the Regional Atmospheric Circulation of Middle Asia during 1961–2016. *Climate*, **8**(9), p.101 (2020) https://doi.org/10.3390/cli8090101
15. Martín-Benito J. M. T., Gómez M. V., and Pardo J. L. Working Conditions of Sprinkler to Optimize Application of Water. Journal of Irrigation and Drainage Engineering, **118**(6), (1992)
16. Playan E., Salvador R., Faci J.M., Zapata N., Martínez-Cob A., and Sanchez I. Day and night wind drift and evaporation losses in sprinkler solid-sets and moving laterals. Agric. Water Manag., **76**(3), pp.139–159 (2005)
17. Rakhmatullaev S., Huneau F., Le Coustumer P., and Motelica-Heino M. Sustainable irrigated agricultural production of countries in economic transition: challenges and opportunities (a case study of Uzbekistan, central Asia). In F. C. Wager (Eds.), Agricultural Production p.32 (2010)
18. Arifjanov A., Samiev L., Khaydarov S., Kasimov T., Juraev S. Increasing Efficient Use of Water Storage Pools. AIP Conference Proceedings, **2432**, (2022)
19. Sokolov V. Handbook on Water Resources Management in Uzbekistan. (2018)
20. Waller P. and Yitayew M. Irrigation and drainage engineering. Springer International Publishing, Cham., p. 747 (2016) https://doi.org/10.1007/978-3-319-05699-9