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# EVALUATION OF THE DISCHARGE COEFFICIENT'S EFFECT ON WATER DISTRIBUTION IN THE SPRINKLER IRRIGATION SYSTEM

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**Abstract**

In the article, experimental work was carried out on the evaluation of the influence of the discharge coefficient on the distribution of water in the sprinkler irrigation system. The experiment was carried out at the university's educational scientific training place located in Urtachirchik district of Tashkent region. During the study, the amount of discharge from each nozzle of the sprinkler was measured. Also, the amount of change in the length of the water distribution was measured. According to the obtained results, the discharge coefficient was calculated according to the formula for calculating discharge in pipes. According to the calculated values, the connection of the flow coefficient, pressure and tap diameters was made. The sprinkler irrigation system selected to ensure uniform wetting was evaluated during the experiment. It is known that the average discharge of 1-1.5 liters of water per second from the selected sprinkler brand and 0.6 atm. from the filter station pressure loss and 3 different radiuses were determined. The distribution radius was determined according to the output discharge and sprinkler rotation frequency. The effect and change of head loss on discharge was evaluated. A general formula for the coefficient of resistance affecting discharge was developed. As a result of the research, the relationship between the water flow rate from the sprinkler and the change in the diameter of the nozzle was brought. It is possible to calculate the amount of the coefficient representing the discharge resistance by entering the values of the sprinkler pressure and the diameter of the nozzle through the connection.

**Key words:** sprinkler, discharge, discharge coefficient, water distribution

# СПРИНКЛЕР СУҒОРИШ ТИЗИМИДА СУВ ТАҚСИМОТИГА САРФ КОЭФФИЦИЕНТИНИНГ ТАЪСИРИНИ БАҲОЛАШ

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**Аннотация**

Мақолада Спринклер суғориш тизимида сувнинг тақсимланишига сарф коэффициентининг таъсирини баҳолаш бўйича тажриба ишлари амалга оширилган. Тажрибалар Тошкент вилояти Ўрта Чирчиқ туманида жойлашган университет ўқув илмий полигонида олиб борилди. Тадқиқот давомида спринклернинг ҳар бир жўмрагидан чиқаётган сув сарфининг напор ўзгаришидаги миқдори ўлчанди. Шунингдек, сув тақсимланиши узунлигининг напор ўзгаришидаги миқдори ўлчанди. Олинган натижаларга кўра, қувурларда сарфни ҳисоблаш формуласига асосан сарф коэффициенти ҳисобланди. Ҳисобланган қийматларга кўра, сарф коэффициенти, босим ва жўмрак диаметрлари боғланиши тузилди. Бир хилда намлатишни таъминлаш учун танланган Спринклер суғориш тизимига тажриба давомида баҳо берилди. Маълум бўлишича, танланган спринклер маркасидан ўртача секундига 1–1,5 л сув сарфланиши ва фильтр станциядан 0,6 атм. босим йўқолиши ҳамда 3 хил радиуслар аниқланди. Чиқаётган сув сарфлари ва спринклерни напор ўзгаришига кўра сув тақсимланиш радиуси аниқланди. Босим йўқолишининг сув сарфга таъсири ва ўзгариши баҳоланди. Сув сарфига таъсир этувчи қаршилик коэффициенти учун умумий формула ишлаб чиқилди. Тадқиқотлар натижасида Спринклердан чиқаётган сув сарфи коэффициентининг босим ва жўмрак диаметри ўзгаришидаги боғланиши келтирилди. Боғланиш орқали спринклерда напор ва жўмрак диаметри қийматларини киритиб, сарфга қаршиликни ифодаловчи коэффициент миқдорини ҳисоблаш мумкин бўлади.

**Таянч сўзлар:** спринклер, сув сарфи, сарф коэффициенти, сувнинг тақсимланиши

# ОЦЕНКА ВЛИЯНИЯ КОЭФФИЦИЕНТА РАСХОДА НА РАСПРЕДЕЛЕНИЕ ВОДЫ В СИСТЕМЕ ДОЖДЕВАЛЬНОГО ОРОШЕНИЯ

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**Аннотация**

В статье проведены экспериментальные исследования по оценке влияния коэффициентам расхода на распределение воды в дождевальной системе орошения. Эксперимент проводился в учебно-научном полигоне университета, расположенного в Уртачирчикском районе Ташкентской области. В ходе исследования измерялся расход воды из каждого краника спринклера, измерялась величина изменения длины распределения воды. По полученным результатам был рассчитан коэффициент расхода по формуле расчета труб. По рассчитанным значениям определена связь коэффициента расхода, давления и диаметра крана. В ходе эксперимента оценивалась система дождевания, выбранная для обеспечения равномерного увлажнения. Известно, что средний расход воды 1–1,5 литра в секунду от выбранной марки дождевателя. Определены потери давления 0,6 атм. на фильтровой станции и 3 различных радиуса. Радиус распределения определялся по расходу воды на выходе и частоте вращения дождевателя, оценивалось влияние и изменение потерь напор на расход воды. Разработана общая формула коэффициента сопротивления, влияющего на водопотребление. В результате исследований была приведена зависимость между расходом воды из дождевателя и изменением диаметра крана. По этой зависимости можно рассчитать величину коэффициента, сопротивления, путем ввода значений давления спринклера и диаметра крана.

**Ключевые слова:** ороситель, водопотребление, расходный коэффициент, распределение воды

**Introduction.** Today, there are several problems in the implementation and design of water-saving irrigation technologies, and several studies are being conducted to find solutions to these problems. According to Darko and others, the sprinkler irrigation system differs from other irrigation systems in that it can uniformly moisten the field and consumes less energy. If the water flowing out of the sprinkler does not wet the field uniformly, it causes excessive costs and affects the growth phase of the crop as well [1]. According to Li and Rao, the sprinkler irrigation system is an irrigation method that can provide the crop area with water and fertilizers at the same time and has high efficiency [2]. Dechimi and others note that sprinkler irrigation system design should be properly implemented, and to hydraulic calculations should be given a great importance [3]. He showed that the uniformity of the sprinkler irrigation system affects the plant growth phase [4]. Sezen and Yazar stated that the frequency of irrigation is important in the effectiveness of sprinkler irrigation system [5]. Also, according to Keller et al., it was considered in the experiments that its faucets are important in the sprinkler irrigation system and that it is of great importance in the equal distribution of the irrigated area and in evaluating the efficiency of water use [6]. The method of irrigation is usually chosen considering such factors as the growth and development of the growing crop, keeping the soil moisture in a normal state compatible with the plant growth phase, and the effect on the land reclamation [7]. Controlling the discharge of the selected irrigation type, controlling its correct operation and distribution is a very complex process [8]. After designing any irrigation method, problems may arise in its practical application. Because in practice there are processes that are not visible and difficult to consider [9]. Irrigation efficiency is an important component of irrigation system management, as uniform distribution of discharge across the field and pressure is a component of the irrigation scheme [10]. Demand for water resources, rising energy costs, climate change, and impacts on groundwater resources will further increase the importance of irrigation efficiency [11]. A poorly managed and designed PIS results in non-uniform water circulation. In such irrigation practices, the maximum valued result of the evaluation method is irrigation water uniformity. The UC is an important gauge of how unequal or equal the application rates (AR) are after the transporting technologies [12]. The output of crops is directly related to the water quantity and method of irrigation used. It is advised that performance evaluation be carried out soon after the irrigation system is installed and then revisited on an irregular basis, especially when considering plans, due to their susceptibility to changing operating conditions over time [13]. Seven FSS in terms of field distribution efficiency was evaluated. They find out that the UCs of FSS fluctuated from 66 to 84%. In the meantime, the UC of FSS fluctuated from 59 to 78% [14]. Researchers also stated that the UC was outstanding, reasonable, and meager outputs of 75 to 85%, 65 to 75%, and 50 to 65%, respectively [15]. The most proficient irrigation techniques are surface irrigation, subsurface, sprinkler, micro-irrigation, and hybrid irrigation. The standard results obtained for water application and irrigation efficiency for each of the above systems are 68% for the solid set, 95% for subsurface drip, 74% for the floppy system, and 82% for the center pivot system [16]. The sprinkler performance helps to differentiate the selection of a method for cropping system. In a highly efficient irrigation system, evaporation losses, distribution uniformity, and wind drift are the primary factors that measure the sprinkler system's performance [17]. Sprinkler performance was analyzed by the distribution pattern, droplet size, application rate, wetted radius, and water discharge. The variation in hydrant, sprinkler spacing, layout, design, or weather situations causes heterogeneity in sprinkler irrigation systems [18]. The sprinkler design's wind direction or speed ignoring may affect the peak flow of water capacity in the sprinkling irrigation system. High wind speed is disfavored in the design management and reliability of the sprinkler system in irrigation [19]. A recent study revealed the consequences of pulsating pressure on uniformity distribution of sprinklers sloping land. It concluded that 10% higher uniformity on pulsating pressure than constant pressure. The study evaluated the sprinkler system's performance at the Kakara Tea Irrigation System (KTIS). It was determined that the Coefficient of uniformity results are 90.9 % and 79% of the delivery performance ratio [20].

Problem statement. When designing a sprinkler irrigation system, due to the change in head from the characteristics of the pump in its hydraulic calculation, there are cases of non-uniform distribution of the discharge and throw radius from the sprinkler. This causes uneven distribution of water throughout the irrigated area. Taking this into account, it is necessary to calculate the resistance that resists the discharge in the head loss. Through this, it is possible to calculate the change of discharge and throw radius during head loss and to carry out the design accordingly.

Consequently, an innovative sprinkler is being introduced to compare the irrigation performance of indigenous sprinklers manufactured with local and original experiment sprinklers. The prime objective of this research was to simulate the experimental data and achieved the field results. (Table 1).

***Table 1***

***Mean Discharge rate (m³/h) of different sprinklers at various pressure and diameter of nozzles.***

| Experiment type | Nozzle diameter mm | Operating pressure | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1.5 bar | | 2 bars | | 3 bars | |
| Experiment in written | 8 | 1.65 | 11.3 | 2.02 | 13 | 2.3 | 15 |
| | 6 | 1.1 | 8.5 | 1.76 | 9.5 | 2 | 11.2 |
| | 5 | 0.75 | 6.2 | 1.34 | 7.3 | 1.52 | 8.9 |
| Experiment in polygon | 8 | 1.57 | 10.5 | 1.84 | 12.5 | 2.84 | 14.5 |
| | 6 | 0.9 | 7.7 | 1.08 | 8.3 | 1.86 | 9.6 |
| | 5 | 0.63 | 5.3 | 0.76 | 6.2 | 1.18 | 7.4 |

The sprinkler parameters given in Table 1 can be seen in the manufacturer's catalog and the differences in the results of field studies. In this case, the difference between the amount of discharge coming out of each nozzle of the sprinkler and the radius of its distribution during the pressure change was significantly seen in field studies and in the quantities of the manufacturing enterprise. For example, if the discharge of an 8 mm nozzle at a pressure of 1.5 bar is 1.65 $m^3/h$ in the amount given by the company, this amount has decreased to 1.57 $m^3/h$ in field conditions. Considering the fact that the field experience and the difference between the values of parameters given by the company and their amount have a great influence on the effectiveness of the sprinkler, it is an urgent task to carry out this field research.

Theory. Studying the natural conditions of the area where the sprinkler irrigation system is installed, measuring the discharge coming out of the sprinkler in seconds and considering the difference in head. To give conclusions on the estimation of the discharge of water coming out of the pipe and the coefficient of discharge.

***Fig. 1. View of the research site from Google Map desktop***

To conduct the experiment, a field area (Fig. 1) with a sprinkler irrigation system installed and working, main pipes, a pump and filter station, sprinkler types and indicators, and equipment such as a pressure gauge were needed. The SEMPA-TKF-80-160-22KW type pump produced in Turkey with a head of 40 m and a discharge of 130 $m^3/s$ was used in the experiment (Fig. 2, 3).

***Fig.2 Pump type***


***Fig.3 Sprinkler type***

In water filtration, water was taken from a pool of 150 m3 and cleaned using the type of filter in Fig. 4:

***Fig. 4. Filter station in research polygon***

Fig. 5 from the manometer to measure the pressure during the experiment, the pressure entering and leaving the filter station was considered. The distribution was calculated according to the pressure entering the sprinkler.

Internal pressures were measured at a minimum of 10 locations distributed throughout each sprinkler system after installation per design. During the experiment, the air temperature, wind speed and direction were considered according to the information provided by the Hydrometer. That is, the air temperature was 37°C, the wind speed was 11 km/h, and the humidity was 12%. The volumetric method was used to measure discharge. According to it, the discharge of water coming out of at least 4 sprinkler nozzle was measured at least 3 times and the average values were considered.

*Fig. 5. Manometers in progress of research*

*Fig. 6. The process of the experiment*

In order to measure the discharge coming out of the sprinkler nozzle when the sprinkler was not rotating, each bucket was placed in a plastic bucket with a volume of 5 liters. The time taken to fill the bucket was recorded with a stopwatch for each combination, and the observations were repeated three times to obtain the accuracy of the results. The water collected in the bucket was measured using a cylinder and the results were recorded. The radius wetted by each sprinkler was measured at different pressures from 10 m to 20 m with gradually increasing pressure in increments of 2 m water column. The radius was measured from 10 sprinklers along the taps of 3 from each sprinkler (Figure 6).

Results. The discharge in the experimental area was calculated using the volume method as mentioned above. Table 2 shows the change of discharge in different efforts. In this case, the change of discharge in every 2 m of water column was calculated from the pressure in 10-20 m of water column. Each experiment was measured 3 times and the average discharge was recorded in the table. On this basis, a graph of changes in the discharge of large and small nozzle with increasing effort was made (Table 2).

***Table 2***

***The difference between pressure and discharge***

| № | Discharge Q l/s, (Sprinkler big nozzle) | Discharge Q l/s, (Sprinkler medium nozzle) | Discharge Q l/s, (Sprinkler small nozzle) | Head H, m |
|---|---|---|---|---|
| 1 | 0.35 | 0.2 | 0.14 | 10 |
| 2 | 0.39 | 0.22 | 0.16 | 12 |
| 3 | 0.42 | 0.24 | 0.17 | 14 |
| 4 | 0.45 | 0.26 | 0.18 | 16 |
| 5 | 0.48 | 0.28 | 0.20 | 18 |
| 6 | 0.51 | 0.30 | 0.21 | 20 |

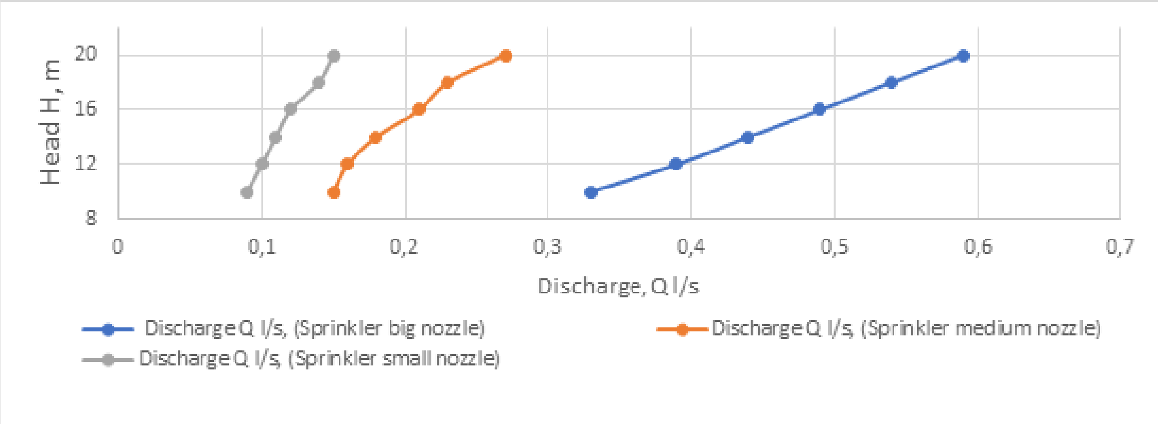


*Fig. 7 Changes in discharge from large, medium and small nozzle according to the increase in pressure*

During the experiment, the pressure increased to 2 meters of water column (10-18m) and the change during this increase was analyzed with a mathematical expression. As can be seen from the (Fig. 7), as the pressure increased, the discharge also increased. During the experiment, an increase in the firing radius was observed as the workload increased. The throw radius of three nozzles of the selected sprinkler model was measured and the following result presented (table 3). It can be visible in Fig 8.

***Table 3***

***The link between the thrust and the radius of the throw***

| № | Head H, m | Radius, R m big nozzle | Radius, R m medium nozzle | Radius, R m small nozzle | Middle results |
|---|---|---|---|---|---|
| 1 | 10 | 8.3 | 5.8 | 4.5 | 6,2 |
| 2 | 12 | 9.2 | 6.4 | 4.8 | 6,8 |
| 3 | 14 | 10.1 | 6.9 | 5.1 | 7,37 |
| 4 | 16 | 10.9 | 7.5 | 5.5 | 7,97 |
| 5 | 18 | 11.6 | 7.9 | 5.8 | 8,43 |
| 6 | 20 | 12.5 | 8.3 | 6.2 | 9,0 |

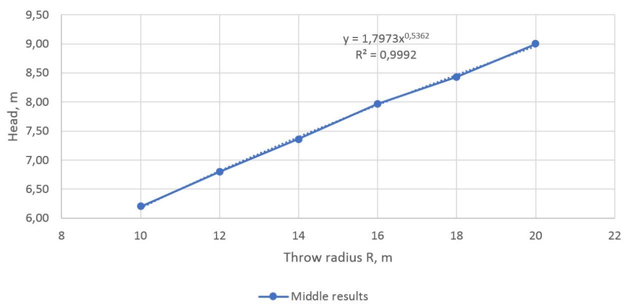


***Fig 8. The graph of the relationship between the head and the throw radius***

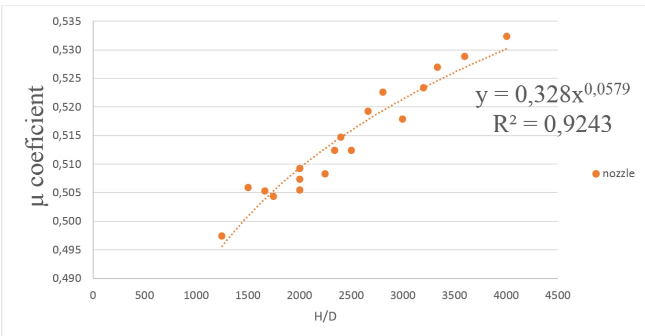


***Fig 9. The graph of the discharge coefficient μ and the ratio of the nozzle diameter to the pressure D/H***

Discussion. According to the experience gained for determining discharge, the possibility of determining the discharge coefficient according to the amount of water coming out of the sprinkler nozzle, that is, according to the pressure and surface, is achieved by the following formula [17]:

$$Q=\mu\omega\sqrt{2gH} \tag{1}$$

here, Q-discharge, $m^3/s$; μ - discharge coefficient; ω-section surface; g-free fall acceleration; H-head. From [1]:

$$\mu = \frac{Q}{\omega\sqrt{2gH}} \tag{2}$$

we reach According to the formula [2], the discharge coefficient μ was calculated according to the change in head for each nozzle and written in Table 4:

As a result of the Fig. 9, the following equations were obtained:

$$\mu = 0.32 * \left(\frac{H}{D}\right)^{0,05} \tag{3}$$

Considering the water coming out of the sprinkler irrigation system and the throw radius, a large nozzle is important, and this nozzle is the main one for supplying water to the crop field. In the next calculations, the change in discharge was determined using the formula (3) calculated. For this purpose, the change of pressure was checked at 4 points from the irrigated area. The discharge coefficient and the change of discharge were considered through the determined amounts of effort.

*Table 4*

***Discharge coefficient μ for 3 nozzles***

| № | D | H/D | Q, m³/s | H, m | Coeff. μ |
|---|---|---|---|---|---|
| 1 | 0,008 | 1250 | 0,00035 | 10 | 0,497 |
| 2 | | 1500 | 0,00039 | 12 | 0,506 |
| 3 | | 1750 | 0,00042 | 14 | 0,504 |
| 4 | | 2000 | 0,00045 | 16 | 0,506 |
| 5 | | 2250 | 0,00048 | 18 | 0,508 |
| 6 | | 2500 | 0,00051 | 20 | 0,512 |
| 1 | 0,006 | 1667 | 0,00020 | 10 | 0,505 |
| 2 | | 2000 | 0,00022 | 12 | 0,507 |
| 3 | | 2333 | 0,00024 | 14 | 0,512 |
| 4 | | 2667 | 0,00026 | 16 | 0,519 |
| 5 | | 3000 | 0,00028 | 18 | 0,518 |
| 6 | | 3333 | 0,00030 | 20 | 0,527 |
| 1 | 0,005 | 2500 | 0,00014 | 10 | 0,509 |
| 2 | | 3000 | 0,00016 | 12 | 0,515 |
| 3 | | 3500 | 0,00017 | 14 | 0,523 |
| 4 | | 4000 | 0,00018 | 16 | 0,523 |
| 5 | | 4500 | 0,00020 | 18 | 0,529 |
| 6 | | 5000 | 0,00021 | 20 | 0,532 |

As can be seen from (Table 7) and it's result in (Fig. 11), the decrease in pressure affects discharge. This prevents the self-shoot radius from decreasing and providing the crop area with uniform moisture. Taking this into account, the calculation of various resistances in pipes, including the coefficient of resistance to discharge, serves to provide the crop area with uniform moisture and increase the efficiency of the sprinkler. For this, it is necessary to consider the discharge coefficient when designing a sprinkler irrigation system.

Conclusions and suggestions. As a result of this field research, which was carried out to ensure the correct operation of the sprinkler irrigation system, increase its efficiency and provide uniform moisture to the field, the existence of a discharge coefficient that affects discharge and thereby other parameters, it was determined that it should be considered during the design process. Also, the effect of the change in effort on the discharge coefficient and thus the discharge resistance was shown. According to it, the formula for determining the resistance coefficient (3) for the nozzle in the sprinkler irrigation system was determined. Through this formula, it was found that the change of discharge and its influence on the radius of self-shooting and, most importantly, on uniform wetting of the field. According to the results of calculations, the pressure fell from 15m to 14 m, 12 m, 10 m and the discharge coefficient was equal to 0.54, 0.528, 0.502, 0.473, respectively. These results caused discharge to drop to 0.464 l/s, 0.438 l/s, 0.385 l/s, 0.331 l/s. That is, with the burning of 35% of the energy, the discharge decreased by 30%. Therefore, when designing a sprinkler irrigation system, it is necessary to take it into account, that is, to use these calculations in the distribution of pressure and discharge.

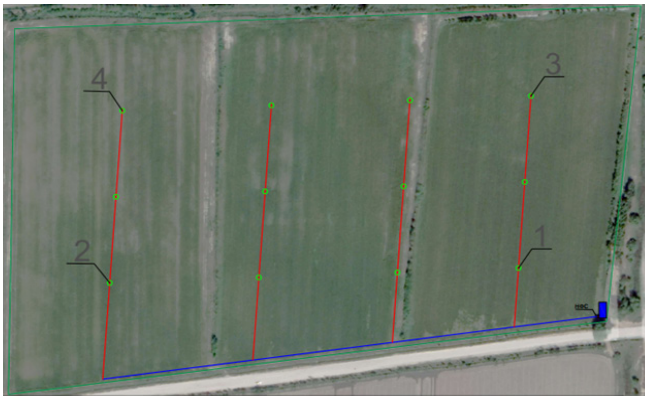


***Fig. 10. A view of the sprinkler irrigation system installed in the experimental area and the points obtained [From Google Earth desktop]***

- Settled sprinklers

1,2,3,4-Taken points

-Polyethylene pipes

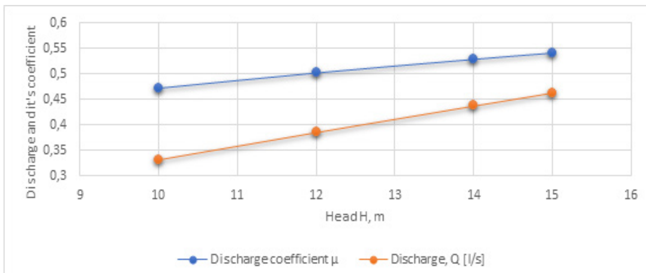


***Fig 11. Graph showing the effect of Head loss on Discharge.***

*Table 5*

***Change in discharge according to the discharge coefficient in the pressure change***

| Points | Head, H m | Discharge coefficient μ | Discharge, Q [l/s] |
|---|---|---|---|
| 1 | 15 | 0.540 | 0.464 |
| 2 | 14 | 0.528 | 0.438 |
| 3 | 12 | 0.502 | 0.385 |
| 4 | 10 | 0.473 | 0.331 |

| № | Адабиётлар | References |
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