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Optimizing Water Purification for Drip Irrigation Systems in Arid Regions to Support Sustainable Development Goals (SDGs)

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ABSTRACT

This study investigates sustainable water purification for drip irrigation in arid regions, with emphasis on Uzbekistan. We also identified filtration strategies that ensure uniform water discharge and protect emitters under varying seasonal conditions. Field observations and comparative analyses of filter performance were conducted in water storage reservoirs, examining sediment accumulation, biological activity, and operational responses. The results indicated that filter surfaces experienced rapid fouling at the beginning of the irrigation season, while water clarity improved in later stages as demand decreased. These inefficiencies emerged because fine particles and aquatic biomass accumulated on filter elements and inside pipelines, increasing resistance and blocking outlets. As a response, the study proposes adaptive, site-specific filtration systems incorporating pre-settlement, screen or disc filters, and scheduled cleaning routines. Implementing such solutions contributes to achieving the Sustainable Development Goals (SDGs), particularly SDG 2 and 6, by enhancing irrigation water quality and promoting agricultural resilience in water-scarce environments. The work also provides practical guidance for system designers and managers seeking resilient, efficient drip irrigation.

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1. INTRODUCTION

Global water scarcity continues to pose significant challenges [1-7]. Especially, recently we have faced issues in sustainable agricultural production [8-10]. With increasing climate variability and growing demands across sectors, agriculture must adopt efficient irrigation methods to meet food security targets. Among these, drip irrigation has emerged as a prominent solution that delivers water and nutrients directly to the root zones of crops, reducing evaporation losses and enhancing irrigation efficiency [11-13].

The efficiency of drip irrigation, however, is highly dependent on the quality of water used. Suspended solids, organic debris, and aquatic weeds in the water supply can lead to emitter clogging, causing uneven water distribution, increased maintenance needs, and ultimately, reduced crop yields [14]. These limitations are especially critical in arid and semi-arid climates, where biological activity and sediment load can vary significantly throughout the irrigation season [15-18].

In the case of Uzbekistan, nearly 90% of its total water resources are consumed by agriculture, but the efficiency of water use remains lower than in countries with similar climatic conditions. On average, between 10,000 and 11,000 cubic meters of water are used annually to irrigate one hectare of land, whereas other nations with comparable environments achieve the same productivity with significantly less water. This inefficiency has prompted the Uzbek government to initiate structural reforms, including the implementation of water-saving technologies such as drip irrigation. And, it is well-written in (i) Presidential Decree of the Republic of Uzbekistan No. PF-6024 dated July 10, 2020, approving the “Concept for the Development of the Water Management of the Republic of Uzbekistan for 2020–2030.” and (ii) Presidential Decree of the Republic of Uzbekistan No. PF-60 dated January 28, 2022, “On the Development Strategy of New Uzbekistan for 2022–2026.”

Despite its potential, the introduction of drip irrigation in Uzbekistan is confronted with site-specific difficulties. Irrigation water, often drawn from rivers or canals and stored in open reservoirs, tends to contain high concentrations of sand, silt, algae, and other organic materials [15,19]. In hot climates, such as those in Uzbekistan, these contaminants proliferate, particularly at the beginning of the irrigation season, leading to rapid clogging of filtration units and distribution lines [17]. The clogging of emitters disrupts uniform irrigation, delays plant development, and contributes to water losses and yield variability [20].

Although several studies have addressed drip irrigation design and filtration technologies, most focus on controlled or generalized environments. Research that integrates field-based measurements of particle size variation, filter clogging dynamics, and seasonal biological growth in open reservoirs remains limited [6,21]. Additionally, many commercially available filtration systems are not adapted to the fluctuating water quality conditions seen in arid zones such as Uzbekistan [20,21].

Designing an effective drip irrigation system requires a multidisciplinary approach that combines hydraulic analysis, water quality monitoring, and field engineering. Parameters such as source water characteristics, filter type and configuration, emitter design, and system layout must be aligned to local environmental realities. In the absence of context-specific filtration strategies, drip systems risk failing to deliver their promised efficiency and longevity.

This study investigates the technical requirements and filtration strategies for drip irrigation systems under the specific conditions of Uzbekistan. The purpose is to analyze seasonal variations in sediment concentration, evaluate the effectiveness of purification systems, and propose adaptive configurations for water treatment. The novelty of this research lies in its focus on real-world data from operational systems in arid zones, addressing

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both mechanical and biological clogging challenges. The expected impact includes improved irrigation efficiency, reduced emitter failure, and contributions toward Sustainable Development Goals (SDGs) (specifically SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation)) through more resilient water use in agriculture.

2. LITERATURE REVIEW

Irrigation plays a fundamental role in enhancing agricultural productivity, particularly in regions where rainfall is insufficient or irregular. It serves not only as a mechanism to stabilize crop yields but also as a critical adaptation strategy in the face of climate variability and increasing water scarcity. The significance of irrigation systems (especially modern methods such as drip irrigation) has been widely recognized in agricultural research, policy, and practice. This is evidenced by the growing volume of scientific literature dedicated to irrigation technologies, water use efficiency, and irrigation system design. Bibliometric analyses consistently show that research output in the field of irrigation has expanded substantially over the past two decades, reflecting its centrality in achieving food security, environmental sustainability, and technological innovation in agriculture (**Figure 1**). Detailed information regarding bibliometrics is explained elsewhere [22]. As such, understanding the evolution of irrigation technologies and the challenges they face, particularly in water-stressed regions, is vital for designing resilient agricultural systems.

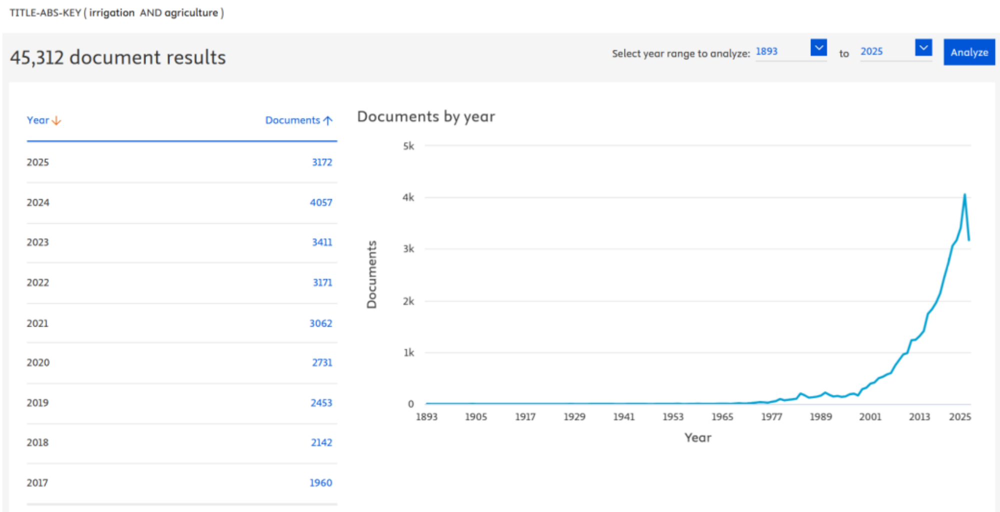

Figure 1. Bibliometric analysis using the keywords irrigation and agriculture, taken from the Scopus database in September 2025.

Figure 2 presents a visual comparison of two crop fields using drip irrigation, where differences in uniformity highlight the impact of emitter clogging and water distribution problems. Drip irrigation has been widely recognized as an effective strategy to enhance water use efficiency in agriculture. It delivers water directly to plant root zones, minimizing losses due to evaporation and runoff. This system is especially beneficial in arid and semi-arid environments, where efficient water use is essential for crop productivity [11-13]. However, its performance is highly dependent on the quality of the irrigation water.

Emitter clogging is a major issue that affects the functionality of drip irrigation systems. This occurs due to the presence of mechanical particles such as sand and silt, chemical deposits including calcium and iron compounds, and biological contaminants like algae and aquatic weeds [15]. When these materials accumulate, they block the narrow passages in filters and emitters, resulting in reduced flow, system inefficiency, and non-uniform irrigation [16].

Various filtration technologies have been introduced to mitigate these problems. Common types include screen filters, disc filters, sand media filters, and hydrocyclones. These systems differ in their ability to remove particles of varying sizes and compositions, and their effectiveness depends on the water source characteristics and system layout [17]. Screen and disc filters are effective against inorganic particles, while sand filters perform better against organic matter. Despite these options, choosing the correct configuration remains challenging in field conditions.

Figure 2. View of two types of crop fields irrigated through a drip irrigation system. Note: 1 is the Field irrigated uniformly, and 2 is the Field irrigated unevenly.

The local context of Uzbekistan introduces several complications that require careful consideration in filter design. Water used in agriculture is commonly taken from open canals and reservoirs, which are susceptible to biological contamination and sediment inflow. As temperatures rise in the spring and summer seasons, the biological activity in these reservoirs increases rapidly, leading to the growth of algae and aquatic weeds. These conditions contribute to rapid filter clogging and degradation of irrigation performance [17].

Studies have shown that high concentrations of fine particles, especially during the early stages of the irrigation season, pose a significant challenge to filtration systems. In April, for example, suspended solids in the water tend to include large proportions of particles smaller than 0.005 mm. These particles bypass standard filters, settle in pipelines, and reduce overall system efficiency [17]. This reduction in performance can lead to pump efficiency losses of up to thirty-two percent and uneven water delivery to crops [17].

Recent experimental and field-based studies have explored improvements in filtration systems for drip irrigation. These include the use of self-cleaning mechanisms, modular filtration units, and adaptive layouts to address variable water quality. However, many of these innovations remain untested or unadapted to the specific climatic and hydrological conditions of arid regions like Uzbekistan [16,20,21].

In practical terms, filtration systems can be arranged in various configurations depending on site conditions. **Figure 3** illustrates four basic layout schemes: centralized filtration units, distributed units near the field, gravity-fed designs, and two-sided groundwater intake systems. These configurations vary in terms of their complexity, energy requirements, and suitability for different terrain types [20].

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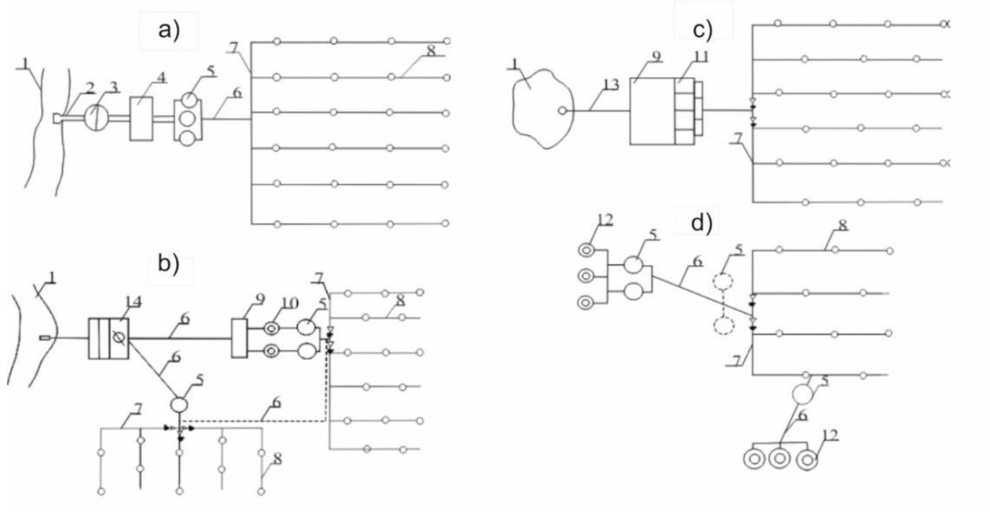

Figure 3. Layout schemes for the placement of purification facilities in drip irrigation systems. Figure (a) is a centralized water purification system that supplies the irrigation network from one side; Figure (b) is a system with distributed water purification facilities located near the irrigated area; Figure (c) is a centralized water purification system with a gravity water supply; and Figure (d) is a distributed scheme for groundwater intake and purification with two-sided feeding of the irrigation network. Detailed legend is the following: 1 = Water source; 2 = Gravity pipeline; 3 = Bank well; 4 = First-stage pumping station; 5 = Floating-bed pressure filters; 6 = Pressure pipelines; 7 = Main pipelines; 8 = Distribution pipelines; 9 = Regulating sedimentation basins; 10 = Suction chamber of the second-stage pumps; 11 = Floating-bed non-pressure filters; 12 = Groundwater intake (wells); 13 = Gravity conduit; 14 = Bank-type water intake.

Despite the available configurations and equipment, current systems often fall short when faced with seasonal changes in water quality. Existing research typically addresses only part of the problem, without integrating mechanical, biological, and operational variables into a unified design framework [21]. There is a clear need for comprehensive field studies that monitor particle dynamics and system performance across different periods of the irrigation cycle.

This review highlights a gap in the literature concerning adaptive, site-specific water purification strategies for drip irrigation in arid climates. Most solutions are not tailored to manage fluctuating sediment loads, biological contamination, and varying operational conditions. These challenges suggest that current models may not be sufficient for sustained application in regions with water quality variability, such as Uzbekistan [17,20,21].

The present study responds to this gap by offering a field-based assessment of filter performance, clogging behavior, and seasonal water quality changes. It aims to inform the design of more resilient, efficient filtration systems for drip irrigation. The expected contributions support SDG 6 by improving access to clean water in agriculture, and SDG 2 by enhancing food production through improved irrigation efficiency.

3. METHOD

The research methodology consisted of field-based observations, system diagnostics, and quantitative calculations focused on filtration performance in operational drip irrigation systems. The study was conducted in several farms in the Tashkent region where drip irrigation has been installed and maintained under typical Uzbek agricultural conditions.

These sites were selected due to their representative environmental factors, including source water conditions, reservoir types, and climatic influences.

Multiple components of the drip irrigation system were observed, including pump performance, water supply pipelines, emitter functionality, and the buildup of particulate and biological materials inside the distribution network. Field monitoring revealed several recurring technical problems, such as low filtration efficiency, pump malfunctions, emitter clogging, and sediment accumulation, particularly during the early irrigation season [15–17].

To assess the water purification demands of the system, two primary formulas were used to determine required flow rates and internal system needs. The total flow rate required by the system was calculated using the following expression, presented as Equation (1).

$$Q_s = T.Q_t + Q_{ie} \tag{1}$$

where *Qs* is the total daily water supply needed for irrigation, including filter operations (m³/day); *T* is the number of operational hours per day; *Qt* is the maximum hourly water consumption for irrigation (m³/hour); *Qie* is the volume of water required for internal filter station needs (e.g., screen washing, station cleaning, etc.).

The internal water consumption of the purification system itself was calculated using Equation (2), which accounts for maintenance operations such as cleaning filters and backwashing sand media.

$$Q_{ie} = K.Q_t \tag{2}$$

Where, *Qie* is the water used for internal needs of the filtration system (m³/day); *Qt* is the maximum hourly irrigation water demand (m³/hour); *K* is the coefficient representing the fraction of water required for filter station operations, typically ranging from 0.01 to 0.03 based on international practice [17].

Selection of purification equipment and system configuration was based on several field variables: distance from source to field, type and level of suspended particles, shape and length of pipeline networks, emitter specifications, and the area under irrigation. Different filter types were evaluated in context, including screen filters for coarse sediment, disc filters for medium particle loads, and sand filters for biological and organic contaminants. These were assessed based on their operational flow rate, ease of maintenance, and frequency of clogging.

During the study, water samples were collected from reservoirs during different months, with a focus on April and September to capture early-season and late-season characteristics. Particle size distribution was analyzed in a lab setting to determine the proportion of suspended solids in the water supply, which informed the assessment of filtration effectiveness and clogging behavior.

Clogging rates and flow rate reductions were measured in real time using pump performance logs. Observations showed that filter surfaces were most vulnerable to clogging during April, when biological growth in the reservoir was at its peak. These clogging events directly impacted the discharge rate from emitters, leading to irregular water application across the field. Data were compared across different filtration layouts and operational parameters to evaluate which configurations were most effective in minimizing flow loss and emitter blockage.

All observations and calculations were used to develop recommendations for system improvements, including filter sizing, configuration placement, and periodic maintenance scheduling. The field-based approach ensured that the methodology was rooted in practical performance realities, rather than idealized laboratory conditions.

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4. RESULTS AND DISCUSSION

4.1. Reservoir Pollution Dynamics

Figure 4 illustrates the natural pollution process observed in water reservoirs used for drip irrigation. This visual documentation shows the proliferation of aquatic vegetation and the accumulation of organic matter near the water surface. Such biological activity intensifies under high-temperature conditions, particularly at the beginning of the irrigation season. These processes contribute significantly to the overall degradation of irrigation water quality and directly influence the effectiveness of purification systems.

Figure 4. Natural pollution process of the water reservoir.

Water reservoirs in the observed sites were prone to contamination due to both natural and anthropogenic factors. Naturally occurring pollution stemmed from rainwater runoff, erosion of reservoir banks, and the biological growth of algae, duckweed, and other aquatic flora. These phenomena were especially prevalent in spring months when temperatures rose and nutrient availability increased. In addition, artificial disturbances such as improper maintenance of inlet channels and accumulation of crop residues accelerated the deterioration of water quality [17].

The consequence of these pollution dynamics is the influx of suspended organic materials, including plant debris, silt, and biological matter, which enter the reservoir and are subsequently drawn into the irrigation system. These substances present a significant challenge to drip irrigation, as they lead to blockages in filter surfaces and emitter outlets, disrupting uniform water distribution. The presence of decaying plant matter also contributes to the formation of biofilms and increases microbial activity, further complicating the treatment process [17].

Field monitoring indicated that reservoirs lacking regular cleaning schedules or pre-sedimentation basins exhibited higher levels of visible contamination. As the organic load increased, the initial filters installed at these locations began to clog within shorter operational intervals. This not only reduced filtration capacity but also increased system downtime due to the need for frequent manual cleaning. These findings highlight the necessity of integrating reservoir management as a fundamental part of any drip irrigation purification design.

Furthermore, biological contamination showed seasonal fluctuations. In April, during early irrigation activities, the reservoirs showed maximum biomass accumulation and floating vegetation. This biological loading was observed to decline slowly toward September, although sediment and fine particles remained suspended in the lower layers. The observations support the conclusion that filtration systems should be designed to handle peak-season contamination, not just average annual values.

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4.2. In-Pond Filter Condition

Figure 5 shows the condition of the in-pond filter installed at one of the experimental sites. The image clearly illustrates the physical clogging of the filter surface caused by sediment, fine particles, and aquatic vegetation residues. This evidence provides a direct visual representation of the operational challenges faced by filtration equipment during peak irrigation periods.

Figure 5. The water purification filter is installed in the pond in a polluted condition.

During site inspections, filters were evaluated based on their retention capacity, ease of maintenance, and frequency of clogging. The installed filter was designed to trap large particles, such as sand and plant fragments, before they entered the distribution pipelines. However, as **Figure 5** indicates, the actual load placed on these filters was far beyond their intended design capacity, especially during the early months of the irrigation cycle.

Operators reported that filters required cleaning up to twice a day during high-load periods in April and May, compared to once every two or three days in later months. This cleaning frequency was due to the presence of dense mats of algae and decomposed vegetation that adhered to the filter mesh. The accumulation of such materials led to an increase in pressure loss across the filter, reducing water delivery rates and requiring manual intervention for restoration [17].

In systems without pre-filtration settling tanks, suspended solids bypassed the initial filter stage and were carried into the main filtration units, compounding the risk of emitter clogging. These operational inefficiencies underline the importance of designing multi-stage purification schemes, beginning with gross particle removal through sedimentation or coarse filtering, followed by fine filtration for small particulate and biological materials.

The observations also highlighted differences in performance depending on filter type and installation method. Filters located directly within the pond or at the intake point faced higher contamination loads compared to those placed downstream in enclosed chambers. Submerged filter heads were particularly vulnerable to rapid biological fouling. These findings suggest that the physical placement and protective housing of filters play an essential role in long-term system functionality.

In addition to visual observations, water samples were taken upstream and downstream of the filter. The turbidity values and visible sediment presence showed a significant decrease post-filtration during the early weeks of operation. However, as the filter became saturated, effluent quality deteriorated, indicating a loss in filtering efficiency. This finding underscores

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the need for automated cleaning mechanisms or self-cleaning filters, especially in water bodies with highly dynamic contamination profiles.

4.3. Particle Size and Seasonal Variation (Partial)

Figure 6 shows the distribution of particles in the irrigation water collected during April and September, reflecting seasonal variations in contamination levels. These particle sizes were analyzed in laboratory conditions using sedimentation and sieving techniques. The results demonstrate a clear shift in the size and concentration of suspended solids between the beginning and end of the irrigation season.

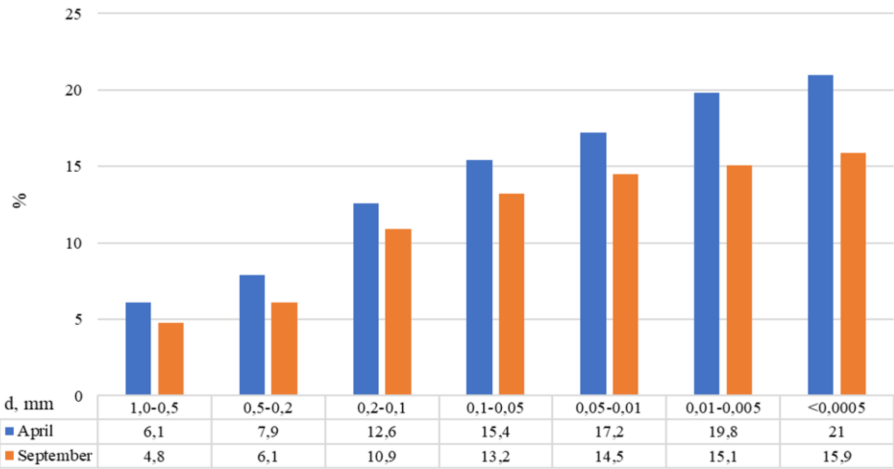

Figure 6. The quantity of particles in the water supplied to the drip irrigation system.

The early irrigation season, particularly in April, was characterized by a high concentration of fine suspended particles, many of which were below 0.05 mm in diameter. These particles include silt, clay, organic detritus, and microbial aggregates. Such materials are small enough to bypass coarse filters and accumulate within emitter channels, leading to clogging. The proportion of particles below 0.005 mm was highest during April, forming the majority of the total suspended load [17].

As the season progressed, a relative decrease in fine particles was observed in September. This trend is attributed to reduced water withdrawal from the reservoir, lower biological activity due to cooling temperatures, and sedimentation of larger particles over time. In later months, the water clarity improved slightly, but contamination persisted at levels capable of impairing system performance, particularly if filters were not maintained regularly.

Laboratory measurements confirmed that filtration systems need to be tailored not only to average particle size but also to seasonal extremes, especially during the first few weeks of active irrigation. This is the period when particle influx is at its highest and systems are most vulnerable to clogging. Filters that function adequately under average conditions may still fail under seasonal peaks, resulting in service interruptions and crop stress.

The variation in particle sizes also had direct consequences on filter surface loading rates. Filters with standard mesh sizes were unable to retain particles smaller than 0.05 mm, allowing them to pass into downstream pipelines. Once inside the irrigation lines, these particles gradually settled and formed internal deposits, especially at pipe joints and in emitters with low-pressure zones. As the deposits accumulated, they reduced effective pipe diameter and disrupted water flow uniformity across the field [17].

These findings emphasize the importance of matching filter specifications to the particle size distribution of the local water source, which is not constant throughout the year. In

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systems where water sources are seasonal or reservoir-based, the initial weeks of high withdrawal carry not only increased water volume but also more intense suspended sediment loads. This situation requires dynamic filtration strategies that allow for increased filtration surface area or self-adjusting backwash cycles.

In addition, bio-organic aggregation was observed to increase during spring due to microbial growth, forming small gelatinous clusters that, although physically small, were sticky and contributed significantly to filter fouling. These clusters were especially difficult to remove with conventional screen or disc filters, underscoring the need for complementary treatment technologies, such as sand media or chemical dosing, depending on site conditions.

Thus, understanding seasonal variation in particle size and type is fundamental to designing robust, long-term drip irrigation systems. Ignoring this variability can lead to underperformance of filters, increased maintenance burdens, and failure to deliver uniform irrigation during the most critical growth stages of crops.

4.4. Hydraulic Impact on Pump Delivery

Figure 7 illustrates the decline in water flow rate over time as a result of filter surface clogging. This figure is based on field measurements taken at the main pump outlet, comparing clean filter conditions to progressively fouled states during operational cycles. The data show that flow rates decreased significantly (by up to thirty-two percent) over a short time span due to increased head loss across clogged filter surfaces.

At the beginning of the irrigation cycle, clean filters allowed for stable pressure and flow delivery. However, as particles and biological matter accumulated on the filter media, resistance increased, requiring the pump to work harder to maintain pressure. This not only reduced flow output but also increased energy consumption, putting additional strain on pumping units [17].

Pressure gauges installed before and after the filtration units showed a growing differential pressure, confirming hydraulic losses associated with surface fouling. In some cases, the pumps entered cavitation zones, producing vibrations and system noise due to unstable intake flow conditions. Operators were forced to interrupt irrigation cycles to manually clean filters, which caused delays in water delivery and interrupted irrigation schedules.

This decline in flow directly affected emitter discharge rates, especially in end-of-line sections. As pressure dropped, emitters failed to deliver water evenly, resulting in crop zones that were under-irrigated. This non-uniformity led to visible differences in plant growth, with delayed development in areas receiving less water. In turn, this contributed to yield variability and overall productivity loss.

The loss in pump flow also posed long-term risks to system hardware. When filters are clogged and pumps run under pressure stress, motor overheating and mechanical wear occur faster. In several of the studied sites, pump service life was reduced due to irregular operating conditions caused by unfiltered debris and constant overcompensation of pressure.

These results highlight the interconnectedness of filtration performance and hydraulic system behavior. Effective filter maintenance and adequate filtration design not only protect emitters but also extend the functional life of pumps and improve irrigation reliability. Moreover, the integration of automatic pressure monitoring and real-time flow sensors can assist farmers in detecting filter saturation before it leads to operational failure.

4.5. Discussion

The findings presented in this study underscore the critical role of filtration systems in the overall efficiency and resilience of drip irrigation networks, particularly under arid climate

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conditions like those in Uzbekistan. The degradation of water quality due to biological and mechanical contaminants directly impairs the uniformity of water delivery and leads to measurable system losses.

The seasonal nature of contamination (high particle and biological loads in early irrigation months) suggests that filtration systems should be designed not for average loads, but for peak contamination scenarios. Most existing systems fail not because of incorrect theory but due to inflexibility in design, which does not accommodate temporal variations in water quality [17,20,21].

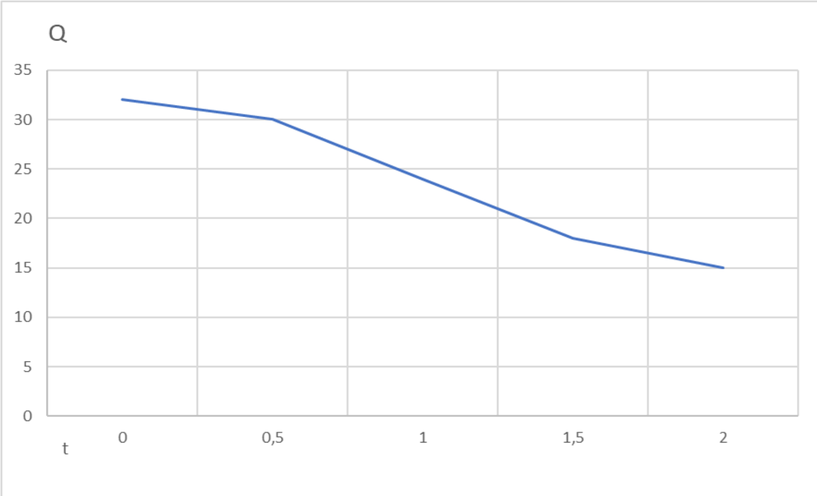

Figure 7. Variation of water flow rate in the drip irrigation system over time due to filter surface contamination.

These results have clear implications for achieving SDGs, particularly:

(i) SDG 2 (Zero Hunger): Improved irrigation reliability contributes to more consistent crop yields, especially in regions vulnerable to climate-induced variability.

(ii) SDG 6 (Clean Water and Sanitation): The study promotes the concept of agricultural water cleanliness as a parallel to drinking water quality, emphasizing the need to treat irrigation water with equivalent rigor.

Additionally, the study identifies several limitations. First, the research was confined to specific farms in the Tashkent region and may not fully represent other areas with different reservoir types or water sources. Second, the filters studied were standard commercial models; alternative technologies such as electrostatic or membrane-based systems were not evaluated. Third, flow variability caused by crop water demand changes was not independently analyzed, although it could further influence filtration behavior.

Given the interdependency between water quality, filter performance, and pump efficiency, the study demonstrates that an integrated filtration approach is essential. Rather than relying on a single type of filter, system designs should incorporate multi-stage purification units that combine sedimentation, coarse screening, and fine filtration. Where biological contamination is high, additional technologies such as floating covers, pre-treatment sedimentation basins, or chemical dosing should be considered to prevent excessive biological growth in reservoirs.

In terms of operational strategy, periodic monitoring of pressure differentials and flow rates across filters should become a standard procedure. This practice enables timely cleaning and helps prevent emitter clogging before it affects field-level irrigation. Furthermore, the adoption of automated or self-cleaning filtration units would substantially reduce labor

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requirements and extend system uptime, especially during peak irrigation months when manual maintenance is least practical.

A broader implication of this study is the reframing of irrigation water quality as not merely a maintenance concern, but as a strategic component of sustainable agricultural productivity. Drip irrigation systems in water-scarce regions must be designed with equal emphasis on hydraulic performance and water treatment capability. By doing so, system reliability is improved, crop stress is minimized, and resource efficiency is maximized.

The study supports SDG 2 by improving the resilience of food production systems through reliable irrigation infrastructure. It also reinforces SDG 6, not only by emphasizing the importance of clean water for human consumption, but also by elevating the standards for water used in agriculture. This adds new information regarding SDGs, as reported elsewhere (**Table 1**).

Table 1. Previous studies on SDGs.

No	Title	Ref
1	Sustainable development goals (SDGs) in engineering education: Definitions, research trends, bibliometric insights, and strategic approaches	[23]
2	Sustainable packaging: Bioplastics as a low-carbon future step for the SDGs	[24]
3	Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting SDGs	[25]
4	HIRADC for workplace safety in manufacturing: A risk-control framework and bibliometric review to support SDGs	[26]
5	Techno-economic analysis of production ecobrick from plastic waste to support SDGs	[27]
6	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the SDGs	[28]
7	Definition and role of sustainable materials in reaching global SDGs completed with bibliometric analysis	[29]
8	Bibliometric insight into materials research trends and innovation to support SDGs	[30]
9	Physical adaptation of college students in high-altitude training to support SDGs	[31]
10	Enhancing job satisfaction through HRIS and communication: A commitment-based approach to SDGs	[32]
11	Enhancing innovative thinking through theory-based instructional model to support SDGs	[33]
12	Influence of self-efficacy on affective learning outcomes in social studies education toward achieving SDGs	[34]
13	Enhancing occupational identity and self-efficacy through self-education in art/design aligned with SDGs	[35]
14	Integrating generative AI-based multimodal learning in education to enhance literacy aligned with SDGs	[36]
15	Dataset on Sulawesi schools and cultural implications to support SDGs	[37]
16	Enhancing professional readiness in vocational education aligned with SDGs	[38]
17	School feeding program and SDGs in education: Linking food security to learning outcomes	[39]
18	Influence of eco-friendly packaging on consumer interest to meet SDGs	[40]
19	SDG 12 implementation through lemon commodities and waste reduction	[41]
20	Mediterranean diet patterns and sustainability to support SDGs	[42]
21	Education on food diversification through infographic to improve SDGs	[43]
22	Safe food treatment technology to achieve SDG zero hunger and optimal health	[44]

5. CONCLUSION

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This study evaluated the performance and limitations of water purification systems used in drip irrigation under the environmental conditions of Uzbekistan. Field-based observations revealed that seasonal variations in particle concentration and biological activity directly impacted the efficiency of filters and the uniformity of irrigation. Mechanical particles and aquatic biomass led to rapid clogging of filters, resulting in a decrease in pump flow rates by up to thirty-two percent. Filtration systems were found to be underdesigned for peak contamination periods, especially in early spring. The findings highlight the importance of adaptive, site-specific filtration designs that account for sediment characteristics and biological loading. By addressing filtration as a core component of drip irrigation design, the study contributes to the broader goals of agricultural sustainability. The results provide empirical support for improving irrigation reliability, reducing water losses, and aligning irrigation infrastructure with SDG 2 and 6.

6. ACKNOWLEDGMENT

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

8. REFERENCES

[1] Qizi, P.M.B., and Lolayevich, S.J. (2023). Improvement of the technology of industrial wastewater treatment in the mining industry. *ASEAN Journal for Science and Engineering in Materials*, *2*(1), 45-52.

[2] Sarkingobir, Y., and Tukur, U. (2025). Plastic in water and its implications in human and biological systems. *ASEAN Journal for Science and Engineering in Materials*, *4*(1), 1-12.

[3] Ashraf, A., Abbas, S.M.A., Saleem, S., Bibi, S., Akbar, R., Zurat-Ul-Jannat, Z., Hamdani, G., and Hussain, N. (2025). Review on adsorption and photocatalysis of dyes for wastewater treatment. *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 109-120.

[4] Kpega, T.C., Habila, J.D., Okon, I.E., and Ekwumemgbo, P.A. (2026). Photocatalytic removal of toxic metals from tannery wastewater using green synthesized zinc oxide nanoparticles. *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 1-8.

[5] Benito, B.S.A. (2023). A step-by-step experimental procedure for water quality assessment of blue lagoon: Comparison to socio-demographic and economic profile for a teaching model. *ASEAN Journal for Science Education*, *2*(2), 107-120.

[6] Fiandini, M., Hofifah, S.N., Maryanti, R., Al Husaeni, D.F., Al Husaeni, D.N., and Nandiyanto, A.B.D. (2023). Education of water hyacinth. *ASEAN Journal for Science Education*, *2*(2), 129-140.

[7] Satria, R.D., and Nandiyanto, A.B.D. (2022). Education of dietary habit and drinking water quality to increase body immunity for elementary school. *ASEAN Journal of Agricultural and Food Engineering*, *2*(1), 25-32.

[8] Permatasari, N., Sucahya, T.N., and Nandiyanto, A.B.D. (2016). Agricultural wastes as a source of silica material. *Indonesian Journal of Science and Technology*, *1*(1), 82-106.

[9] Febriani, D., and Pasaribu, P.T. (2024). Food security strategy through regenerative agriculture for capacity building of farmers with "integrated nutrient management training program". *ASEAN Journal of Community Service and Education*, *3*(1), 49-54.

[10] Umar, A., Gbenga, A.A., Yusuf, M.-N. O., Faridah, A., Emmanuel, A.T., and Adekitan, A.F. (2025). Production and characterization of briquettes from agricultural wastes for sustainable energy solutions. *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 121-136.

[11] Yang, P., Wu, L., Cheng, M., Fan, J., Li, S., Wang, H., and Qian, L. (2023). Review on drip irrigation: impact on crop yield, quality, and water productivity in China. *Water*, *15*(9), 1733.

[12] Vasiliev, S. M., Korzhova, T. V., and Shkura, V. N. (2017). Technical means of drip irrigation. *Scientific Journal of the Russian Research Institute of Land Reclamation Problems*, *3*, 159.

[13] Шкура, В. Н., and Штанько, А. С. (2021). Компоновочные решения модулей оросительной сети капельно орошаемых древесно-плодовых растений, культивируемых в садовых насаждениях. *Мелиорация и гидротехника*, *11*(4), 157-173.

[14] Muhammad, T., Zhou, B., Puig-Bargu, J., Ding, C., Li, S., Manan, I., and Li, Y. (2022). Assessment of emitter clogging with multiple fouling and root intrusion in sub-surface drip irrigation during 5-year sugarcane growth. *Agricultural Water Management*, *274*, 107981.

[15] Zong, Q., Liu, Z., Liu, H., and Yang, H. (2019). Backwashing performance of self-cleaning screen filters in drip irrigation systems. *PloS one*, *14*(12), e0226354.

[16] Usatyi, S., and Usata, L. (2022, November). Monitoring observations on changes in irrigation water quality. *In 16th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment*, *1*, 1-5.

[17] Abou-Shady, A., Siddique, M. S., and Yu, W. (2023). A Critical review of innovations and perspectives for providing adequate water for sustainable irrigation. *Water*, *15*(17), 3023.

[18] Новикова, И. В., Лунева, Е. Н., and Грицай, А. В. (2019). Средства и технологии водоподготовки для капельного орошения сельскохозяйственных угодий. *Мелиорация и гидротехника*, *3*(35), 1-17.

[19] Yang, P., Wu, L., Cheng, M., Fan, J., Li, S., Wang, H., and Qian, L. (2023). Review on drip irrigation: impact on crop yield, quality, and water productivity in China. *Water*, *15*(9), 1733.

[20] Al-Mefleh, N. K., and Al-Raja, O. B. F. (2020). Impact of irrigation water quality and envelope materials around drip line on emitter performance in subsurface drip irrigation. *Water and Environment Journal*, *34*(1), 14-24.

[21] Wang, T., Guo, Z., and Kuo, C. T. (2019). Effects of mixing Yellow River water with brackish water on the emitter's clogging substance and solid particles in drip irrigation. *SN Applied Sciences*, *1*(10), 1269.

[22] Al Husaeni, D.F., and Nandiyanto, A.B.D. (2022). Bibliometric using VOSviewer with publish or perish (using Google Scholar data): From step-by-step processing for users to

DOI: https://doi.org/10.17509/ajse.v6i3.90502
p- ISSN 2776-6098 e- ISSN 2776-5938

the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. *ASEAN Journal of Science and Engineering*, *2*(1), 19-46.

[23] Ragadhita, R., Fiandini, M., Al Husaeni, D.N., and Nandiyanto, A.B.D. (2026). Sustainable development goals (SDGs) in engineering education: Definitions, research trends, bibliometric insights, and strategic approaches. *Indonesian Journal of Science and Technology*, *11*(1), 1-26.

[24] Basnur, J., Putra, M.F.F., Jayusman, S.V.A., and Zulhilmi, Z. (2024). Sustainable packaging: Bioplastics as a low-carbon future step for the sustainable development goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *3*(1), 51-58.

[25] Sesrita, A., Adri, H.T., Suherman, I., Rasmitadila, R., and Fanani, M.Z. (2025). Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting sustainable development goals (SDGs): A techno-economic and bibliometric analysis. *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 245-266.

[26] Henny, H., Budi, A.H.S., Andriyansyah, M., Ar Rozzak, M.R., Baru, M.M., and Masek, A. (2025). Hazard identification, risk assessment, and determining control (HIRADC) for workplace safety in manufacturing industry: A risk-control framework complete with bibliometric literature review analysis to support sustainable development goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *4*(2), 267-284.

[27] Syahrudin, D., Roestamy, M., Fauziah, R.S.P., Rahmawati, R., Pratidina, G., Purnamasari, I., Muhtar, S., and Salbiah, E. (2026). Techno-economic analysis of production ecobrick from plastic waste to support sustainable development goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 9-16.

[28] Apriliani, A., Waahyudin, C., Ramdani, F.T., Martin, A.Y., Syahrudin, D., Hernawan, D., and Salbiah, E. (2026). Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the Sustainable Development Goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 17-36.

[29] Ragadhita, R., Nandiyanto, A.B.D., Farobie, O., Kurniawan, T., and Bilad, M.R. (2026). Definition and role of sustainable materials in reaching global Sustainable Development Goals (SDGs) completed with bibliometric analysis. *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 53-100.

[30] Al-Obaidi, A.S.M. (2026). The Journal of Engineering, Science and Technology (JESTEC): A bibliometric insight into materials research trends and innovation to support Sustainable Development Goals (SDGs). *ASEAN Journal for Science and Engineering in Materials*, *5*(1), 101-122.

[31] Xing, G., Chano, J., Thadanatthaphak, Y., and Wu, C.C. (2025). Physical adaptation of college students in high-altitude training: Empirical findings and curriculum development insights to support Sustainable Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(2), 215-236.

[32] Imaniyati, N., Ratnasari, C.D., and Adman, A. (2025). Enhancing job satisfaction through human resource information systems and communication: A commitment-based approach to achieve Sustainable Development Goals (SDGs) in education-oriented organizations. *ASEAN Journal of Educational Research and Technology*, *4*(2), 237-254.

[33] Di, R., Sawangboon, T., and Chano, J. (2025). Enhancing innovative thinking through a theory-based instructional model in design education to support Sustainable

DOI: https://doi.org/10.17509/ajse.v6i3.90502
p- ISSN 2775-6793 e- ISSN 2775-6815

Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(3), 311-332.

[34] Wiyanarti, E., and Nurjannah, A.N. (2026). Influence of self-efficacy on affective learning outcomes in social studies education toward achieving Sustainable Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(1), 1-18.

[35] Yu, X., Chano, J., and Wongsaphan, M. (2026). Enhancing occupational identity and self-efficacy through a self-education model in art and design education aligned with Sustainable Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(1), 19-46.

[36] Nurjamin, A., Nurjamin, L.R., Fajriah, Y.N., Nurjamin, A.K., and Firdaus, H.A. (2026). Integrating generative artificial intelligence (AI)-based multimodal learning in education to enhance literacy aligned with Sustainable Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(1), 71-88.

[37] Abduh, A., Achmad, S.F., Syam, C., Samad, S., Arham, M., Mustafa, M., and Pandang, A. (2026). Dataset on the number of schools, teachers, and students in Sulawesi, Indonesia: kindergarten, primary, junior, senior high, vocational, and Islamic boarding schools with educational access, quality, and cultural implications to solve challenges and strategies in education management and support Sustainable Development Goals (SDGs). *ASEAN Journal of Educational Research and Technology*, *4*(1), 89-116.

[38] Khamdamovna, K.S. (2025). Enhancing professional readiness in vocational education through an integrative approach aligned with the Sustainable Development Goals (SDGs). *ASEAN Journal for Science Education*, *4*(2), 143-154

[39] Ximenes, S.M. (2025). School feeding program and Sustainable Development Goals (SDGs) in education: Linking food security to learning outcomes in Timor-Leste. *ASEAN Journal for Science Education*, *4*(2), 155-168

[40] Haq, M.R.I., Nurhaliza, D.V., Rahmat, L.N., and Ruchiat, R.N.A. (2024). The influence of environmentally friendly packaging on consumer interest in implementing zero waste in the food industry to meet sustainable development goals (SDGs) needs. *ASEAN Journal of Economic and Economic Education*, *3*(2), 111-116.

[41] Maulana, I., Asran, M.A., and Ash-Habi, R.M. (2023). Implementation of sustainable development goals (SDGs) no. 12: Responsible production and consumption by optimizing lemon commodities and community empowerment to reduce household waste. *ASEAN Journal of Community Service and Education*, *2*(2), 141-146.

[42] Nurnabila, A.T., Basnur, J., Rismayani, R., Ramadhani, S., and Zulhilmi, Z. (2023). Analysis of the application of mediterranean diet patterns on sustainability to support the achievement of sustainable development goals (SDGs): Zero hunger, good health and well beings, responsible consumption, and production. *ASEAN Journal of Agricultural and Food Engineering*, *2*(2), 105-112.

[43] Awalussillmi, I., Febriyana, K.R., Padilah, N., and Saadah, N.A. (2023). Efforts to improve sustainable development goals (SDGs) through education on diversification of food using infographic: Animal and vegetable protein. *ASEAN Journal of Agricultural and Food Engineering*, *2*(2), 113-120.

[44] Rahmah, F.A., Nurlaela, N., Anugrah, R., and Putri, Y.A.R. (2024). Safe food treatment technology: The key to realizing the sustainable development goals (SDGs) zero hunger and optimal health. *ASEAN Journal of Agricultural and Food Engineering*, *3*(1), 57-66.

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