Proceedings of the 7th International Conference on Materials Chemistry and Environmental Engineering
DOI: 10.54254/2755-2721/2027.37445

Multi-parameter Evaluation of Multilayer Gravity Filtration for Ski-Resort Snowmelt Water Pretreatment and Reuse

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Abstract. To address the issues of centralized discharge and resource recovery of snowmelt water, a multi-layered gravity filtration system for snowmelt water discharge in ski resorts was developed using filter cotton, activated carbon, quartz sand, and gravel. The experiment examined the impact of filter media combinations, filter bed thickness, filtration time, treated water volume, and inflow rate on treatment performance, using various parameters to measure it, including pH, turbidity, suspended solids (SS), color, and conductivity. The findings have shown that the composite filter bed is effective in improving the particulate matter content and visual water quality of the snowmelt water, reducing turbidity from 238.2 NTU to 17.2 NTU (removal rate of 92.8%) and achieving a suspended solids (SS) removal rate of 65.97%. The rates of turbidity and SS removal were 91.5% and 71.35%, respectively, when the quartz sand layer was raised to 6 cm. The choice to reduce the inflow velocity appropriately to enhance SS retention efficiency was effective, but conductivity was not reduced in equal measure to the indicators of particulate matter. The process is mainly applicable in the removal of particulate pollutants and can be used as a pretreatment unit for the non-portable reuse of snowmelt water in ski resorts.

Keywords: ski resort snowmelt water, multi-layer filtration, multi-parameter evaluation, suspended solids, resource recovery

1. Introduction

Over the past few years, as the popularity of winter sports and ski resort activities has risen, artificial snowmaking, slope maintenance, and services are consuming increasing amounts of water [1]. The nature of water use in ski resorts is highly seasonal and peaks in the winter months, with other major issues including long distances to water supply, and high water prices [2]. The snow at the resort melts slowly after the operating season, creating surface runoff. When this water is released into the environment, it not only wastes water resources but also overstrains the resort's drainage system and the management of the surrounding environment [3]. Consequently, to eliminate fresh water use in ski resorts and enhance water use efficiency, it is possible to treat snowmelt water and reuse it to irrigate landscapes, clean roads, or dust.

The source of the snow, location, and the activities of the visitors influence the snowmelt water at ski resorts. During snow accumulation and melt, snow mixes with soil, gravel, and surface sediments; consequently, meltwater is likely to contain silt and other suspended solids, leading to

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high turbidity [4]. Site maintenance, vehicle traffic, and the use of de-icing agents can also affect the electrical conductivity of the water. In addition, dead branches, fallen leaves, humus, and other surface organic matter can contribute to meltwater, thus influencing parameters such as chemical oxygen demand (COD) [5]. Even though the pollution of such meltwater is usually minimal, direct reuse can readily obstruct pipes and sprinkler heads and can also affect later use due to changes in water quality [6]. Thus, it is of practical value to perform required filtration and water quality analysis before reuse.

Sand filtration and adsorption treatment offer the benefits of simple equipment, low operating costs, and easy maintenance, and are suitable for water with low pollution load and high concentrations of particulate matter and low concentrations of organic matter [7]. Filter cotton may trap larger suspended contaminants; quartz sand may further reduce water turbidity by sieving and retaining interparticle matter; activated carbon may adsorb dissolved organic constituents and other color- and odor-causing substances. The layer of support is usually composed of gravel that assists in keeping the filter bed in place and enhancing the distribution of water flow [8]. By mixing them, it is possible to retain and adsorb particles simultaneously, so such a solution is highly suitable for the preliminary treatment of snowmelt water in seasonal, decentralized plants such as ski resorts [9]. Nevertheless, the effectiveness of such a simple composite filtration system in treating real ski resort snowmelt water, including the possibility of reusing the treated water, remains to be assessed using specific water quality parameters.

In this regard, this experiment gathered snowmelt water at a ski resort and designed a four-layered composite filtration system by using filter cotton, activated carbon, quartz sand, and gravel. Vital parameters such as turbidity, pH, conductivity, color, and suspended solids were measured in pre- and post-treatment water samples to assess the system's performance in removing particulate matter and other indicators of pollution from the snowmelt water. Based on these findings, the overall analysis of the treatment's effectiveness was conducted using several water quality parameters. There was also a pre-discussion about the possibility of using the treated effluent to irrigate landscapes, clean roads, and suppress dust, with the intention of providing a basis for low-cost treatment and recovery of snowmelt water resources at ski resorts.

2. Materials and methods

2.1. Water samples and experimental materials

The water used in the experiment was collected as surface runoff that developed during the snowmelt season at the Beijing Nanshan Ski Resort. Water samples were collected at three snowmelt runoff convergence locations in the ski resort in March 2026; 2 L of water were sampled at each location as demonstrated in Figure 1. The water samples were placed in clean polyethylene bottles after being labeled and transported to the laboratory at a low temperature for less than 4 hours. They were stored at 4°C in the dark and then subjected to filtration experiments and water quality analysis.

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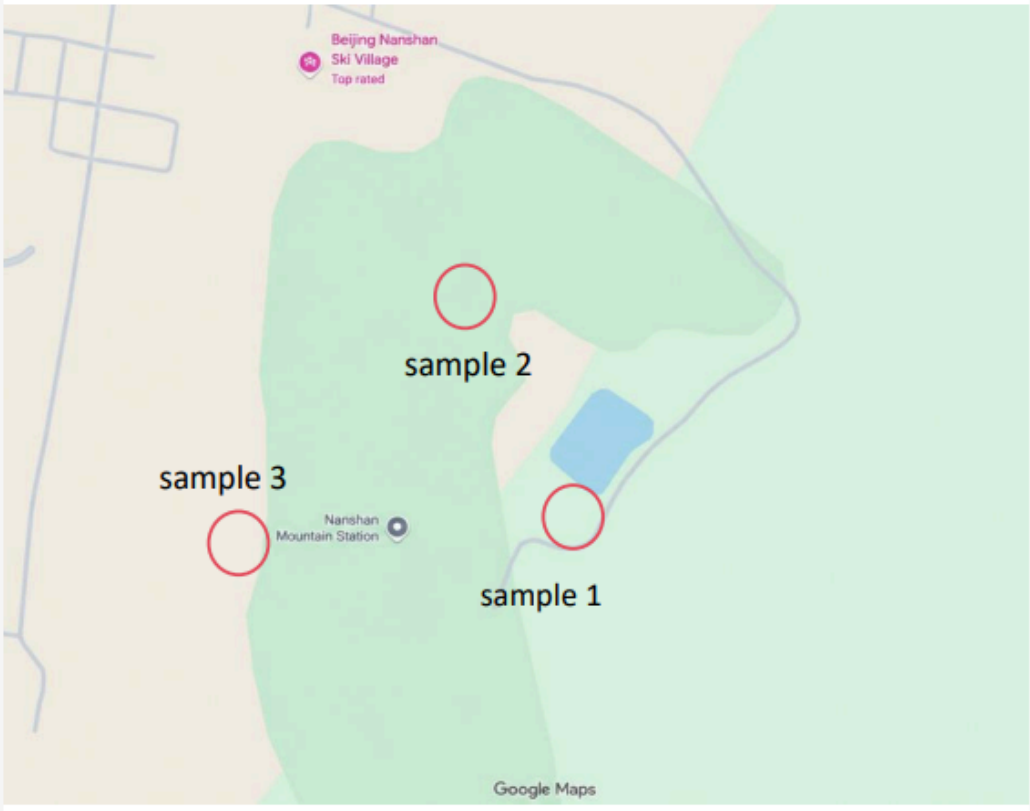

Figure 1. Map of snowmelt water sampling locations at Beijing Nanshan Ski Resort

Filter media include filter cotton, activated carbon in granular form, 10- to 20-mesh quartz sand, and gravel. A typical composite filtration system comprises the four materials listed above in the given order, with each filter layer being 2 cm thick and an overall packing height of 8 cm (Figure 2). The masses of activated carbon, quartz sand, and gravel loaded are 58.6, 101, and 103 g, respectively. The filtration column is made up of a plexiglass column with an inner diameter of 10 cm.

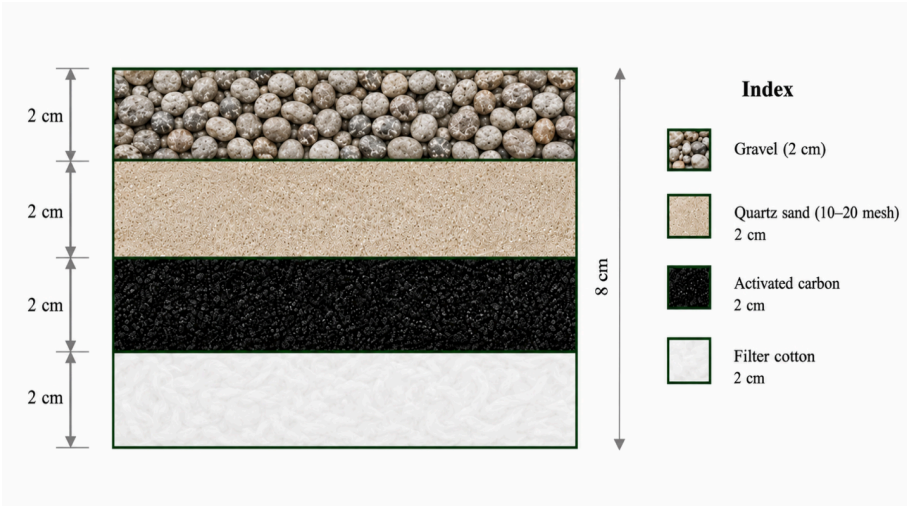

Figure 2. Schematic cross-sectional view of a standard filtration unit (filter cotton: FC, activated carbon: AC, quartz sand: QS, and gravel: GR)

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2.2. Multi-layer filtration system and experimental design

Meltwater is filtered as it flows through the column under gravity. To study the influence of the filter media composition on purification, the following four filter media combinations were created: Group A included a full composite filter bed of filter cotton, activated carbon, 1020 mesh quartz sand, and gravel; Group B included quartz sand and gravel; Group C in addition to the quartz sand and gravel was filter cotton, and Group D included in addition to the quartz sand and gravel was activated carbon. The effluent water quality of the groups was compared to assessing the ability of various filter media to retain particulates and improve water quality.

The impact of filter bed thickness and the nature of operation on treatment performance was also examined after identifying the composite filtration system. The quartz sand filter beds were placed at depths of 2, 4, and 6 cm to measure the effects of filtration depth on water quality, and alternative filtration times were also set to measure the effects of the filtration process on effluent water quality. The treatment test loads were varied to 100, 200, and 300 mL of influent, and the effects of hydraulic conditions on the performance of the filtration process were studied by varying the influent flow rate. Except for the specific variables, all other experimental conditions were kept constant. The influent flow rate was maintained at 50 mL/min under normal conditions. Each experimental group was subjected to three parallel experiments to reduce the effects of random errors.

2.3. Determination of water quality parameters

Water samples were analyzed for pH, turbidity, suspended solids (SS), color, and conductivity before and after filtration. Turbidity was measured using a PASCO PS-3215 turbidity meter; pH was determined using a Leizhi SW738 portable pH meter; suspended solids (SS) were determined by the gravimetric method in accordance with *Methods for Monitoring and Analysis of Water and Wastewater* (4th Edition); conductivity (EC) was measured using a portable PS-3210 conductivity meter; all instruments were calibrated according to procedures prior to use, and the measurement process strictly followed the corresponding national standards or authoritative methods.

Pollutant removal rates were calculated using the following formula:

$$\eta = [(C_0 - C_1)/C_0] \times 100\%$$

Where C_0 is the inlet, C1 at the outlet; the same equation can be used to describe the levels of turbidity and SS. A weighted summation was used to perform the overall assessment, with each parameter weighted by its actual importance (turbidity 0.4, SS 0.3, EC 0.2, color 0.1; the weightings sum to 1). The standardized scores for each parameter are multiplied by their weights, and the weighted scores are summed to obtain the total score for each treatment scheme. The schemes are prioritized and optimized on these scores to come up with the most desirable solution that is both cost effective and effective in matters of treatment.

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3. Results and discussion

3.1. Effect of filter media composition on snowmelt water treatment performance

There was a high variation in the water quality improvement ability of different combinations of filter media. Figure 3a showed that the pH of the water sample in the full composite filter bed (Group A) was 7.45, and the effluent of the other combinations of the filter media had a pH between 8.20 and 8.34. Overall, the pH was in the neutral to slightly alkaline range, indicating that the filtration process did not introduce a major acid-base imbalance. Regarding the efficiency of particulate matter removal, SS removal rates for the different combinations of filter media ranged from 53.07 to 65.97, with Group A (the overall composite filter bed) showing 65.97 (Figure 3b). Compared with using filter media only in grain form, using filter cotton directly removes small, suspended particles, which is why this technology will provide some benefit in removing SS.

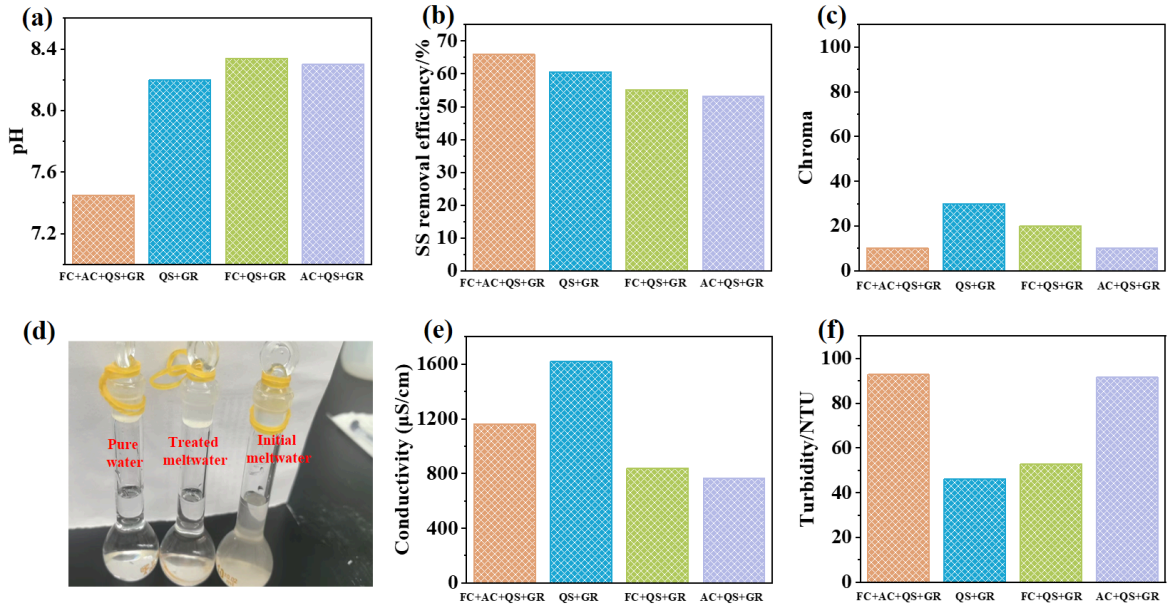

Figure 3. Effects of different filter media combinations(filter cotton: FC, activated carbon: AC, quartz sand: QS, and gravel: GR) on snowmelt water parameters: (a) pH, (b) suspended solids (SS), (c) color, (d) hue, (e) conductivity, and (f) turbidity

Changes in color further reflect the differences in performance among various filter media combinations. After treatment with a complete composite filter bed, the diluted color value was 10, whereas the color values for some simplified filter media combinations reached 20–30 (Figures 3c and 3d). Activated carbon, with its large pore structure and surface adsorption capacity, has a certain removal effect on some color-causing substances; filter cotton and quartz sand, on the other hand, primarily reduce the impact of particulate matter on water appearance through sieving and retention. Therefore, the use of multiple filter media in combination is more effective than a single granular medium in improving the apparent water quality of snowmelt. Changes in electrical conductivity under different combinations did not fully correlate with particulate matter indicators; the conductivity of the effluent ranged from approximately 763 to 1,618 μS/cm (Figure 3e). This means that the filtration system will be effective at controlling suspended particles in the water but not dissolved ions. Sand filtration, filter cotton, and typical granular activated carbon do not necessarily

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exhibit constant desalination capacity; therefore, a drop in turbidity or suspended solids (SS) cannot be directly converted into a drop in salinity in the water (Figure 3f).

Based on a composite of parameters, i.e., turbidity, SS, color, and pH, the multilayer structure, consisting of filter cotton, activated carbon, quartz sand, and gravel, indicated balanced overall performance. Its advantages have nothing to do with any specific filter medium but with the synergistic action of different media: filter cotton is used to retain fine particles, quartz sand is used to sieve out more particles, activated carbon is used to eliminate color and absorb some dissolved matter, gravel is used to provide the system with structural integrity and to distribute water flow.

3.2. Effect of quartz sand filter bed thickness on snowmelt water treatment performance

One important parameter that influences the efficiency of particulate filtration is filter bed thickness. With the addition of the quartz sand layer, the turbidity removal rate showed an overall positive trend, except for the 2 cm and 6 cm layers. The particle removal rates of the 2-, 4-, and 6-cm filter beds were about 42.04, 57.75, and 91.50, respectively; the 6-cm filter bed showed a much higher ability to remove particles (Figure 4a).

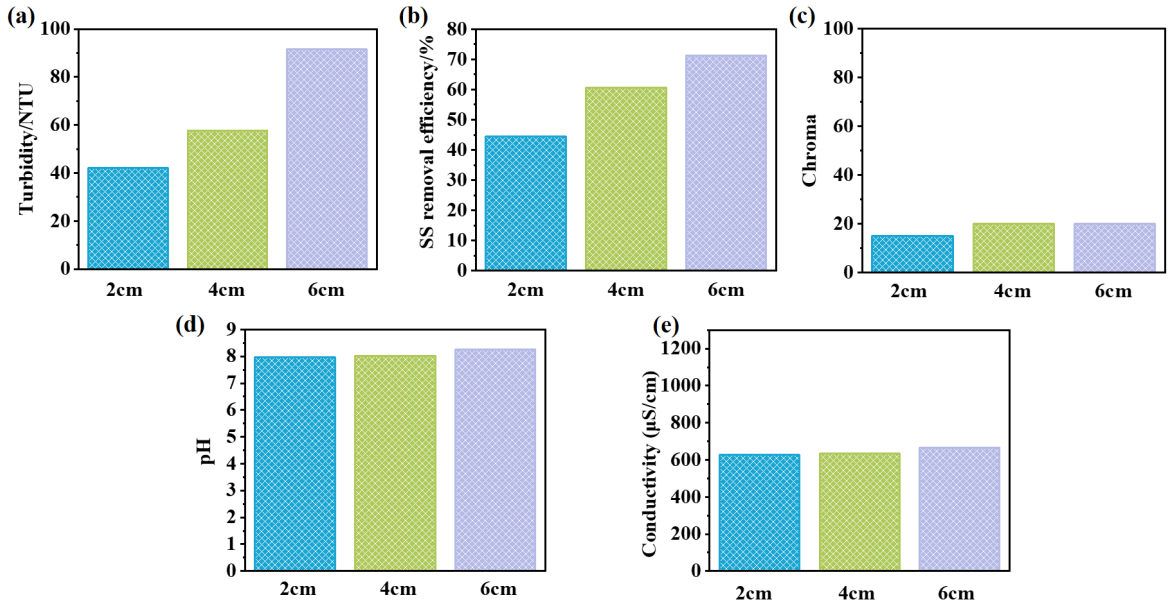

Figure 4. Effect of quartz sand filter bed thickness on snowmelt water parameters: (a) turbidity, (b) suspended solids (SS), (c) color, (d) pH, and (e) conductivity

The variations in SS were usually in line with turbidity. Upon adding 2 cm to 6 cm more sand to the quartz sand layer, the SS removal rate rose to 71.35% as compared to 44.46% (Figure 4b). The deeper the filter bed, the longer the path the particle took through the porous medium, and the more chances it had to collide with, be trapped by, or otherwise come into contact with the filter media; therefore, fine suspended particles had fewer chances of going through the filter bed directly. Simultaneously, the growth in filter bed thickness did not lead to a parallel improvement in all water quality parameters. The effluent pH increased gradually from 7.97 to 8.25 (Figure 4c) under conditions of 2 to 6 cm, with only slight variations; the conductivity was also relatively low, between 627.7 and 666.7 μS/cm (Figure 4d). This also shows that increasing the thickness of the quartz sand layer primarily enhances the physical filtration process rather than the in-depth removal of dissolved ions.

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Operationally, although thickening the filter bed enhances particulate removal efficiency, it increases hydraulic resistance and prolongs the treatment process. This experiment showed that the 6-cm quartz sand layer performed better in terms of purification; however, the filtration time has doubled. As such, in real life, we should not merely aim to achieve a higher filter bed thickness but rather to balance effluent water quality and filtration flux.

3.3. Effect of filtration time on the treatment efficiency of snowmelt water

The filtration time is an influential parameter for the effluent particulate matter. In the first phase of the filtration process, the rate of turbidity removal was quite slow, about 6.21% and 15.63% after 1 and 5 minutes, respectively; at 10 minutes of filtration, the turbidity removal rate rose to 87.50% (Figure 5a). This was also the case with the SS removal rate (Figure 5b). This phenomenon means that small-particle filter beds require some stabilization time during start-up. The water initially flows into a pore network whose structure is not yet fully established. Some finer particles might be carried through the filter bed along the path of the water flow. As filtration progresses, particles will gradually settle in the pores and on the surface of the filter bed, thus increasing the bed's capacity about fine particles.

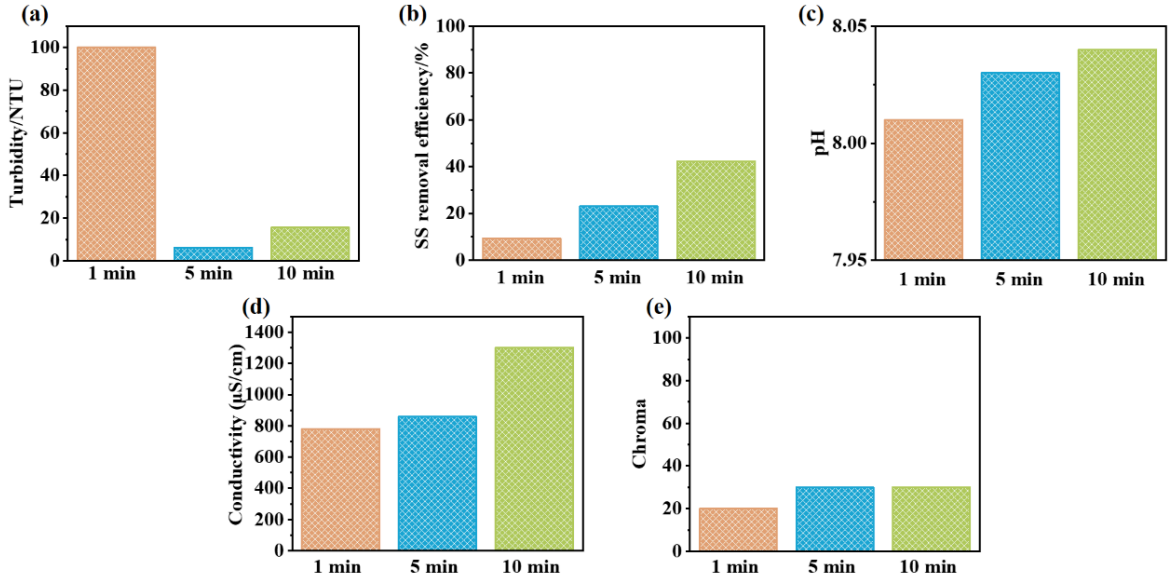

Figure 5. Effect of filtration time on snowmelt water parameters: (a) turbidity, (b) suspended solids (SS), (c) pH, (d) conductivity, and (e) color

It is noteworthy that other parameters did not change consistently. The pH was not significantly affected during the filtration process, varying between 8.01 and 8.04 (Figure 5c), which implies that the acid-base conditions remained fairly constant, whereas the conductivity increased to some extent as filtration progressed (Figure 5d). It implies that an increase in filtration time is favorable for the elimination of suspended particles, but it does not necessarily mean that dissolved constituents and color can be eliminated at the same time (Figure 5e). Thus, the main purpose of this system cannot yet be determined as the removal of particles and pretreatment of snowmelt water, but not as the sophisticated desalination.

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3.4. Effect of treatment flow rate on snowmelt water treatment performance

The filtration system had a high capacity for removing turbidity at flow rates of 100, 200, and 300 mL, with removal rates of 92.83, 83.33, and 90.42, respectively (Fig. 6a). The SS removal rate slowed to 65.97-75.65 percent (Fig. 6b). These findings suggest that, in the range of loads of the treatment load in the current laboratory conditions, the multi-layer filter bed can sustain the fundamental capacities of particulate matter retention. Nevertheless, the responses of various parameters to variations in influent flow rate are not identical. With the increase in treated water volume (100 mL to 300 mL), there was an increase in the diluted color (10 to 25), conductivity (1160.7 to 1803 μS/cm), and pH (7.45 to 8.03). This implies that even though the filtration device will still be effective in eliminating the particulate matter, its treatment potential of dissolved substances and ionic constituents did not increase alongside the filtration action.

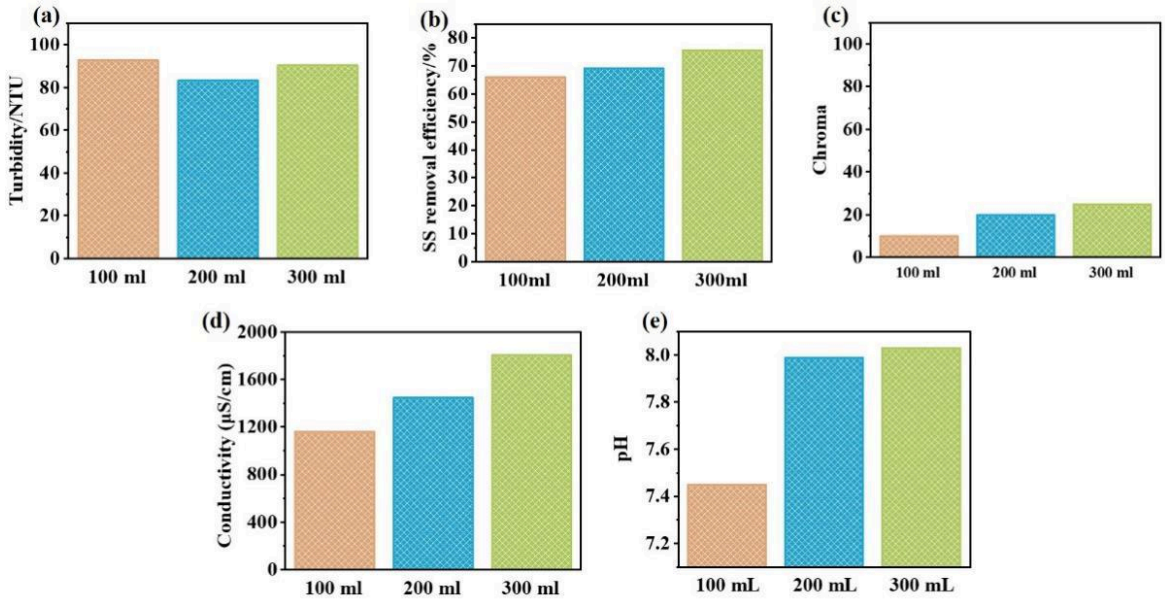

Figure 6. Effect of water volume on snowmelt water parameters: (a) turbidity, (b) suspended solids (SS), (c) color, (d) conductivity, and (e) pH

There are some engineering implications of this difference. Using turbidity as a measurement parameter may easily overestimate the actual reuse capacity of simple filtration systems. Salinity and conductivity of the snowmelt water reuse should also be evaluated. Specifically, with the larger volume of treated water, the sustained treatment capacity of the filter media and the breakthrough problem should also be considered. Moreover, the larger the volume of treated water, the longer the filtration time. The process of filtering a 300 mL water sample takes about 1.5 hours, which means the present device would be better suited to laboratory-scale tests. When applied with continuous on-site treatment, the filtration area needs to be expanded, and the filtration media particle size and hydraulic load should be optimized to provide a higher treatment capacity per unit time.

3.5. Effect of inflow rate on snowmelt water treatment performance

The rate of inflow is an important hydraulic parameter that influences the performance of the multilayer filtration systems. There are some variations in water quality parameters with varying inflow rates. The SS removal rate under slow inflow conditions was 87.47%, which was much

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higher than 65.97% under normal inflow conditions and 63.82% under fast inflow conditions (Figure 7a). This means that as the inflow rate is reduced, so are the residence and migration times of water in the filter bed, permitting the suspended particles to have full contact with media such as filter cotton and quartz sand, thus increasing the efficiency of particle retention. On the other hand, when inflow rates are high, the time water takes to travel through the filter bed is reduced, and some fine particles may more easily penetrate the bed, leading to reduced SS removal effectiveness. There was some consistency in changes of color with the SS results. The effluent color was low under normal and slow inflow conditions, but when the inflow was high, the color rose to about 20 (Figure 7b). This shows that an increased inflow rate not only dilutes particle retention but can also reduce the filter bed's removal efficiency for certain color-causing substances. A fast inflow, on the one hand, shortens the retention time of the particles in the filter bed; on the other hand, it also decreases the effective contact time of the water and the activated carbon, thus impeding the complete achievement of the adsorption process.

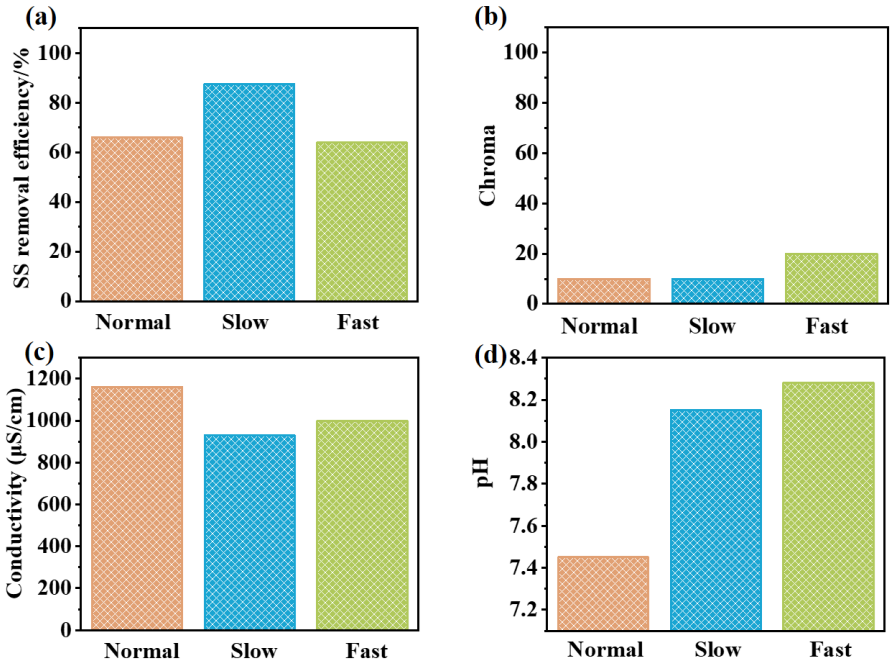

Figure 7. Effect of inflow rate on snowmelt water parameters: (a) SS, (b) color, (c) conductivity, and (d) pH

Conductivity at various inflow rates was approximately 1,160.7, 929.3, and 997 μS/cm, respectively (Figure 7c), and its pattern was not entirely similar to those of SS and color. Electrical conductivity primarily reflects the overall concentration of dissolved ions in the water, whereas other indicators of particulates, like turbidity and SS, reflect particulate levels. The filter media employed in the present research (filter cotton, quartz sand, and granular activated carbon) primarily enhance water quality through physical retention and adsorption and do not exhibit any significant desalination properties. Thus, although the rate of the influent stream can be varied to modify the efficiency of the removal of the particulate matter, its effect on the dissolved salts is not so strong. Moreover, the effluent pH at various inflow rates ranged from about 7.45 to 8.28 (Figure 7d), mostly in the neutral to slightly alkaline range. This means that changes in hydraulic conditions did not significantly affect pH and did not lead to a significant acid-base imbalance. The integration of the

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findings on SS, color, conductivity, and pH indicates that total effluent performance was higher when inflow was slow, which proved very effective in controlling suspended particles and color.

3.6. Analysis of the suitability of snowmelt water reuse

Based on the overall evaluation of turbidity, SS, color, pH, and conductivity, it can be concluded that multi-layer filtration can be successfully used to eliminate particulate pollutants in snowmelt water. Following filtration, all turbidity, SS, and color were reduced, which helped minimize the deposition and clogging of particulate matter in water distribution pipes and sprinkler systems. Thus, when the water quality requirements are not high, as in non-potable uses, such as road washing, cleaning up a site, or dust suppression by spraying with water, this process can be reused to some extent. Modifications in other water quality parameters also show that the elimination of particulate matter is not always indicative of overall high water quality that satisfies reuse requirements. In the experiment, electrical conductivity was not lowered in parallel with turbidity and suspended solids (SS), and this means that traditional filter media-filter cotton, activated carbon, and quartz sand-serve to trap and adsorb particulate matter and not so much to remove dissolved salts. Thus, improvements in turbidity or SS alone are not sufficient to determine the suitability of the treated water for direct use in applications sensitive to salinity and hardness, such as landscape irrigation and artificial snowmaking. The existing outcomes for various parameters also show that this system can effectively control particulate matter but has limited control over dissolved ions.

Based on the existing results, this unit is more suitable as a pretreatment stage in a snowmelt water reuse process. Its particulate-matter removal capacity can be used for low-demand applications, such as road cleaning and dust suppression. Nevertheless, more stringent tests of parameters such as TDS, hardness, major ions, and microorganisms are required in more demanding reuse implementations. The treatment that follows, like softening, ion exchange, or membrane separation, should be introduced as and when required in order to attain the desired water quality.

3.7. Engineering feasibility and optimization directions

As an engineering application, the multi-layer filtration device designed in this research is simple, provides easy access to the filter media, and is easy to operate. Filtration materials are activated carbon, filter cotton, gravel, and quartz sand. It is a gravity-based system and is not a complex power or automatic control system; therefore, it is suitable for small-scale, decentralised snowmelt water pretreatment in ski resorts. With proper topographical variations in the elevation of the land, natural head may be used to facilitate the flow of gravity, and the exercise will be even simpler.

This study has some limitations on its results. The longer the treated water volume, the longer the filtration time, indicating that the given device's treated water throughput is not high. During long-term operation, suspended particles continuously accumulate in the filter cotton and quartz sand layers, which may cause filter bed clogging and increased hydraulic resistance. At the same time, the electrical conductivity did not decrease in tandem with the particulate matter levels, suggesting that this process is not capable of performing desalination. Furthermore, data on filter media service life, replacement cycles, maintenance requirements, and cumulative treated water volume are currently lacking. Therefore, at this stage, the system can only be considered to have some potential for low-cost applications, and its unit water treatment cost cannot yet be accurately evaluated.

Taking into account the treatment performance, operating mode, and major limitations in engineering applications, the engineering performance of this multilayer filtration system and directions for future optimization have been summarized; the results are shown in Table 1.

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Table 1. Evaluation of filtration system engineering performance and optimization strategies

Evaluation Dimensions	Specific manifestations and characteristic descriptions	Impact assessment / Engineering limitations	Response and Optimization Strategies
Material Acquisition and Construction	Using filter cotton, activated carbon, quartz sand and gravel, the structure is simple.	The operation is simple and it has great potential for low-cost application.	Optimize the filling ratio and particle size distribution of the filter material
Power and Operating Modes	Filtration is accomplished by gravity-fed flow, eliminating the need for complex control equipment.	Suitable for decentralized and small-scale pre-treatment of meltwater	Integrate the gravity flow pipelines based on the regional terrain layout of the area
Particulate Matter Control Capability	Significant improvements in turbidity (removal rate > 90%), suspended solids (SS), and color	It can effectively reduce the risk of clogging in the subsequent reuse piping and nozzles	Carry out regular backwashing or maintenance and update of the pretreatment unit
Particulate Matter Control Capability	The processing speed of the laboratory pilot test is relatively slow (about 1.5 hours for 300 mL)	The processing capacity is limited, making it difficult to directly meet the requirements for continuous large-scale processing on-site.	Increase the filtration cross-sectional area and optimize the hydraulic load and influent flow rate
Risk of Filter Bed Clogging	Suspended particulate matter continuously accumulates in the filter cotton and quartz sand layers	The processing capacity is limited, making it difficult to directly meet the requirements for continuous large-scale processing on-site.	Filter cotton/activated carbon should be cleaned and replaced regularly, and quartz sand/gravel should be washed.
Removal of Solute Ions	The electrical conductivity of the effluent did not decrease simultaneously, and its ability to remove soluble salts was limited.	It is not possible to determine, based solely on particulate matter levels, whether water is suitable for high-standard reuse (such as direct irrigation or snowmaking).	Conduct pilot-scale and continuous operation tests to gather additional data for long-term economic feasibility assessments

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Table 1. (continued)

Economics and Cost Analysis	Currently, there is a lack of quantitative data on filter media procurement, effective service life, and replacement frequency.	It is still impossible to precisely calculate the actual operating cost per unit volume for water treatment.	Conduct pilot-scale and continuous operation tests to gather additional data for long-term economic feasibility assessments

As Table 1 indicates, the main benefits of the system are that it is simple to build, requires low operation, and has excellent particulate matter removal effectiveness. Nevertheless, the primary issues that should be taken into account in engineering practice are the treatment throughput, clogging of filter beds, and the removal of soluble salts. Future research should focus on shifting the emphasis from the efficiency of single-pass purification towards continuous operation within the filtration chamber, thereby increasing treatment capacity through a larger filtration area and optimization of the filter bed structure and hydraulic environment, as well as establishing a feasible timeline for the cleaning and replacement of the filter media. Advanced treatment units to be configured as required by reuse pathways with more stringent water quality requirements should be based on real water quality. In addition, the use of filter media, the maintenance schedule to be followed, and the amount of treated water produced should be recorded at the same time the process is in progress, so that they can serve as a basis for future economic analysis and engineering upscaling.

4. Conclusion

A multi-layer gravity filtration process was used in this research to treat snowmelt water at a ski resort, and the treatment performance was assessed in terms of pH, turbidity, suspended solids (SS), color, and conductivity. The main conclusions are as follows:

(1) The mixture of filter media can make a great difference in the purification of snowmelt water. The composite filter bed made of filter cotton, activated carbon, quartz sand, and gravel performed well, reducing turbidity to 17.2 NTU with a removal rate of 92.8 percent and a suspended solids (SS) removal rate of 65.97 percent. Meanwhile, the amount of color was much less, and the pH of the effluent was rather constant. This means that the particle retention, adsorption, and support capabilities of various filter media are complementary.

(2) Filtration structure and hydraulic conditions are other important determinants of the performance of the filtration process. If the thickness of the quartz sand layer was increased to 6 cm, the turbidity and SS removal rates were 91.5% and 71.35, respectively; the filtration time, treated water volume, and inflow velocity also led to varying degrees of change in the water quality parameters. The highest SS removal rate at a low inflow rate was 87.47, indicating that extending the residence time of water in the filter bed to keep particles trapped is worthwhile. Still, the treatment flux should also be considered.

(3) Multi-parameter evaluation shows that the responses of various water quality parameters to the filtration process are not entirely consistent. Although the increases in turbidity, SS, and color were also quite noteworthy, the conductivity did not decline, indicating that this system can increase particulate removal but cannot regulate dissolved salts much. As such, turbidity or SS does not provide sufficient information on whether the effluent is fit for reuse.

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In brief, the unit is characterised by simple construction and filter media that are easily available, and hence is appropriate as a pretreatment unit for snowmelt water in ski resorts. It has some application potential in non-potable reuse pathways with low water quality requirements, e.g., road cleaning and dust suppression by water spraying, but before it can be used in landscape irrigation or artificial snowmaking, further parameter monitoring (TDS, hardness, major ions, and microorganisms) is needed. Continuous operation tests should be run to determine filter bed clogging, treatment flux, and long-term stability.

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