RESEARCH PAPER

Development and Performance Evaluation of a Novel Low-Cost Seven-Stage Water Filtration System (F-7 Filter) for Integration with Atmospheric Water Generation Technology

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ABSTRACT

Accessibility of safe potable water is one of the most important international issues as about 2.2 billion population are deprived of reliably controlled drinking water supply. The Atmospheric Water Generation (AWG) technology is an encouraging technology in providing a decentralized response in water-challenged areas, but after the condensation, purification is necessary to make the water palatable. The paper is a work of developing and overall performance analysis of a new low-cost seven-stage filtration system, the F-7 Filter, which had been specifically designed to be integrated with AWG machinery. The filter media used in the F-7 composite filter is a mixture of copper granules (50 g), silver particles (50 g), alkaline ceramic balls (50 g), calcium sulphite media (50 g), activated carbon (50 g), anti-bacterial ceramic balls (50 g) and gravel substrate (100 g) to form a filter media with the final weight of 700 g. The entire filtration process embraces a polypropylene (PP) sediment filter, then a granular activated carbon pre-filter and finally, the F-7 composite unit prior to the final discharge. At the inlet and outlet ports, fine nylon mesh barriers ensure that there is no media migration and even distribution of hydraulic is maintained. The evaluation of the performance revealed significant positive results in the following critical water quality parameters: the turbidity decrease was more than 94 percent, the stabilization of pH in the optimal range of 7.2-7.4 revealed more than 99.5 percent of reduction of microbial loads within coliform bacteria. Organoleptic evaluation matched extensive improvement in taste and removal of residual odour. Economics showed that the F-7 system attains similar purification efficiency at about 60-70% reduction in capital cost as compared to the traditional reverse osmosis and UV disinfection systems. These results create the F-7 Filter as a promising and relatively cheap and efficient post-treatment solution with AWG applications, especially to implement them in resource-intensive environments and isolated populations.

Keywords: Atmospheric Water Generation; Multi-stage filtration; Low-cost water purification; Antimicrobial filtration; Silver-copper disinfection; Potable water; Sustainable water treatment.

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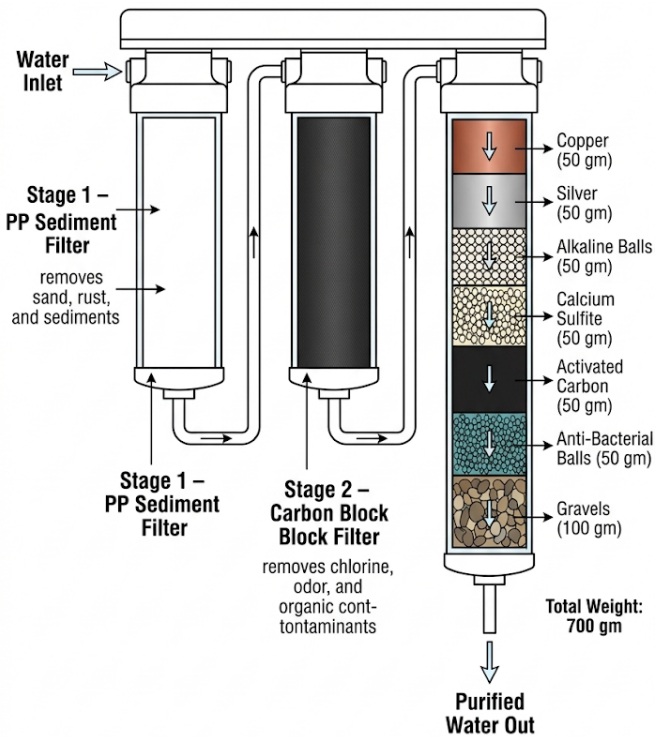

Figure 1. Enhance Multi-stage RO Filtration using F-7 Filter

1. INTRODUCTION

Water crisis all over the world is one of the most urgent issues of modern society. Recent statistics provided by the World Health Organization, as well as the UNICEF Joint Monitoring Programme claim that approximately 2.2 billion people in the world do not have access to safely managed drinking water, with 4.2 billion people having poor sanitation facilities. The populations of arid and semi episodic areas, remote communities with no centralized infrastructures, and urban settlements economically disadvantaged area are disproportionately touched by this crisis as the traditional water distribution networks are ineffective or simply missing(Paliyal & Mondal, 2026).

Although such conventional water purification technologies are effective, they have serious limitations that limit their usability in limited resource settings. Though able to achieve high levels of contaminants removal, reverse osmosis (RO) systems require the use of a large amount of electrical energy (Hosseinpour et al., 2026), their membrane replacement is expensive and requires special skills, and they produce large amounts of reject water which is usually 25-50% of the popular volume further exacerbating the water scarcity issue. The system of ultraviolet (UV) disinfection is effective in pathogen inactivation, but it does not offer any protection to the water following treatment and has low efficiency with turbid water sources. Despite convenience, commercial bottled water causes significant economic pressure on society and maintains substantial levels of economic disinterest Amazonia due to its high cost, produces high amounts of plastic waste, which leads to environmental pollution, and remains economically inaccessible to low-income people to use it on a daily basis(Zafar et al., 2026).

The Atmospheric Water Generation (AWG) technology has appeared an innovative solution to the problem of decentralized water generation that is useful especially in such areas where the underground sources are unproductive or the surface water supply is polluted or is unreliable. AWG systems operate on the principle of removing moisture on the ambient air by condensing water, which is often either thermoelectrically cooled, refrigerated using a compressor, or cooled using a desiccant absorption-regeneration loop(Wang et al., 2026). The resulting condensate, although basically pure water, will still need post treatment to combat any microbial bacterial contamination that may have occurred during collection and storage, get rid of any trace atmospheric contaminants that may have obtained during condensing and improve the consumer acceptability organoleptic attributes of the product.

The need to find low cost, energy saving post-treatment options in regards to use in AWG systems has led to the design of multi-media filtration systems that can take advantage of the synergistic purification effects. These systems combine physical filtration, chemical adsorption, ion exchange or antimicrobial activity into small, low maintenance systems that can fit any location, at the point of use. The adoption of naturally found/ easily produced materials implacable (Zhang et al., 2026), such as metallic antimicrobials

(silver and copper), mineral-based pH modulators, and carbonaceous adsorbents allow filtration systems to be designed, which have high purification efficacies without the use of electrical power or consumable chemical feedstocks.

This paper outlines the systematic design, characterisation, and testing of a new seven stage filtration apparatus, termed the F-7 Filter specifically created to be used with AWG technology. In the F-7 system copper, silver, alkaline ceramic balls, calcium sulphite, anti-bacterial ceramic balls, and gravel are added in specific weights to enable overall water treatment at the re-complimentary level of water purification.(Sadek et al., 2026) The major aims of this research include:

(i)Preparation and development of the F-7 composite filter media in a systematic manner and through fabrication.

(ii) it should be combined with an entire filtration train that contains pre-treatment phase(s); (iii) a thorough study of purification performance in physical, chemical, microbiological, and parameters.

(iv) organoleptic evaluation of subjected water quality.

(v) technological-economic evaluation of F-7 system with other traditional water purification treatments.

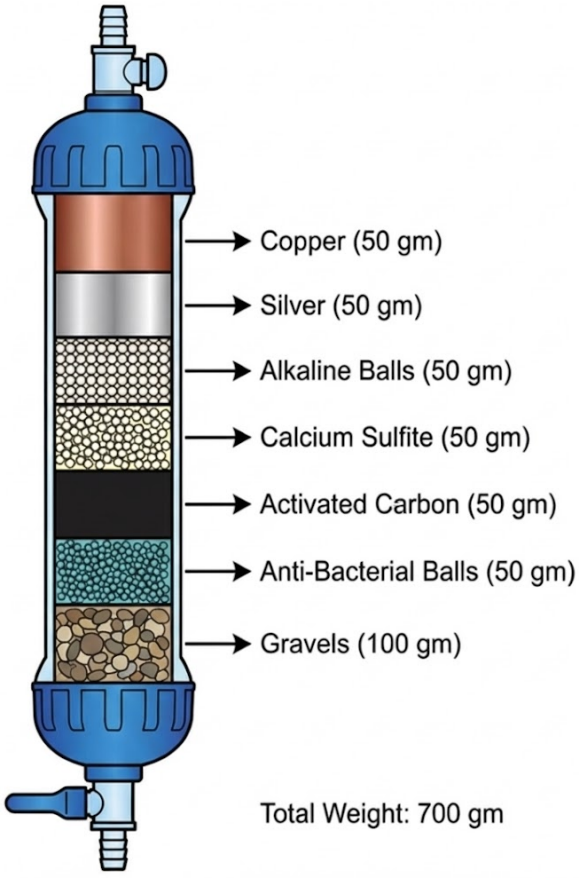

Figure 2. Cross-sectional schematic diagram of multistage filtration unit with components (Legends: Layers are arranged from top to bottom where masses are indicated in grams (gm))

2. MATERIALS AND METHODS

2.1 Atmospheric Water Generation System Configuration

The AWG unit used in the present inquiry is based on the principle of compressor-based refrigeration which utilizes a refrigeration circuit having hermetically sealed walls to obtain surface temperatures that are lower than the dew point of the atmosphere. An axial fan assembly pulls ambient air through a pre-filter mesh and forces it across the evaporator coil where moisture condensation takes place and it is then expelled via the condenser portion. The condensate collection system will contain a stainless-steel tray that would be located directly under the evaporator; the tray would steer the collected water by passing through a gravity feed outlet into the downstream filtration assembly. The operating conditions are ambient temperature of 25-35 deg C, relative humidity of 60-85 percent and nominal water production capacity of 35-40 liters daily, in optimum operation(Qin et al., 2026).

R-410 refrigerant is used in the refrigeration cycle but the temperature of the evaporator surface should be maintained at 5-10degC to maintain a equilibrium condensation and at the same time prevent the formation of ice. The energy intensity of desalination alternatives is much less than energy consumption 0.3-0.5 kWh per liter (Luo et al., 2025) of a water produced that is averagely consumed. Raw condensate has the following characteristic properties: close to neutral pH (6.5-7.0), low dissolved solids (<83 mg/L TDS), low turbidity (<1 NTU) and absence of hardness-related minerals, although it may, in fact, contain microbial contaminants due to atmospheric bioaerosols and contact with collection surfaces..

2.2 F-7 Composite Filter Design and Fabrication

The F-7 filter assembly was developed to operate in a modular cartridge format that can be made to fit in a conventional 10-inch filter housing making it easy to integrate with an existing water treatment system. Optimization trials that evaluate purification efficiency, quantity of hydraulic conductivity, and stability of the selected material were used to arrive at the filter media composition. The developed formulation involves seven different media components sequentially packed in layers in the filter cartridge as shown in Table 1 (Gu et al., 2025).

Table 1: F-7 Filter Media Composition and Functional Specifications

Filter Component	Quantity (g)	Primary Function
Copper granules	50	Antimicrobial action via Cu^{2+} ion release
Silver particles	50	Broad-spectrum disinfection via Ag^{+} oligodynamic effect
Alkaline ceramic balls	50	pH elevation and mineral supplementation
Calcium sulphite	50	Dechlorination and heavy metal reduction
Activated carbon	50	Organic compound adsorption, taste/odour removal
Anti-bacterial balls	50	Sustained antimicrobial release, biofilm prevention
Gravel substrate	100	Mechanical filtration, flow distribution, media support
Total	**400**	

The copper granules used are of electrolytic-grade copper (99.5% purity) particle size ranging between 0.5-2.0 mm which offers the good surface area to dissolve the ions and at the same time the hydraulic permeability is sufficient (Delikanli, 2025). The copper ions (Cu2+) that are liberated when water interacts with it have potent antimicrobial actions in a variety of different ways such as causing membrane destruction, enzyme inactions, and the formation of reactive oxygen species. Calibration of the copper content was undertaken so that it has bactericidal activity and yet does not exceed the WHO guideline of 2 mg/L of copper effluent level(Dong et al., 2025).

Silver particles (99.9 purity, 1.0-3.0 mm particle size) complimentary protection against antimicrobial protection via the established oligodynamic effect. Silver ions show a broad-spectrum effect on bacteria, viruses and protozoan cysts with efficacy against chlorine resistant organisms. The synergic interaction of the edentulous combinations of copper and silver has been widely tested and proved in water treatment works resulting in improved disinfection using lower concentrations of individual metals compared to the sole use.

Alkaline ceramic balls contain sintered mineral compounds such as magnesium oxide, calcium carbonate and tourmaline, which are designed to release positive minerals as well as be able to raise pH levels above the slightly acidic condensate range (6.5-7.0) (Zhao et al., 2025)up to the ideal drinking water range (7.2-7.8). The mineral supplementation will cover the inherently poor mineral levels of the AWG condensate and enhance taste perceptions and offer necessary trace elements(Lo et al., 2025).

Calcium sulphite (CaSO3) is a reducing agent of the chlorine species and precipitates the contaminants of heavy metals. Although AWG condensate generally has very little chlorine, its calcium sulphite component gives safeguard in the event of contamination at the storage and distribution level. Also, the potential of reduction of calcium sulphite helps to reduce the oxidized form of the heavy metal species to the(B. Sun et al., 2025) less soluble form that can be removed physically.

Coconut shell activator to produce activated carbon (iodine number 1000mg/g, BET surface area 1100m2/g) offers high-capacity adsorption to dissolved organic compounds, volatile organic contaminants and low-trace taste /odour causing trace substances. The low-molecular-weight organics such as chlorinated compounds, phenolic substances, and atmospheric contaminants that might be picked up during the condensation process are preferably adsorbed by the microporous structure(Bedair et al., 2025).

Anti-bacterial ceramic balls and ball bearings are such pieces that include silver-impregnated ceramic

substrates and zeolite used as the anti-microorganism releasing material in conditions of prolonged operation. Such composite materials offer residual disinfection capacity to the treated water preventing the development of biofilm in later storage facilities and the further protection through the distribution process(Horcada et al., 2024).

Gravel substrate (2-5 mm particle size- silica based) fulfils several tasks such as mechanical filtration of suspended particulates, even flow distribution throughout the filter cross-section, and support of the reported layers of media. The gravel is thatched at the inlet and outlet points of the cartridge forming a layered structure which avoids media migration and channelling(Y. Sun et al., 2026).

2.3 Filter Assembly and Integration

The F-7 cartridge assembly uses a cylindrical shaped housing (food grade polypropylene), which has internal diameter of 65 mm and effective length of 250 mm, by attaching fine nylon mesh (100-micron aperture) to each inlet and outlet port to hold(Y. Sun et al., 2026) the filter media and allow water to pass freely through the filter. The layers in the media are arranged in considering away towards the inlet to outlet, i.e., gravel (50 g) - copper granules - silver particles - alkaline balls - calcium sulphite - activated carbon - anti-bacterial balls - gravel (50 g). This arrangement allows progressive treatment by complementary action and the final polish in the particulate layer is caused by the topmost layer of grave (Eghlima et al., 2026).

The full filtration train used includes three consecutive processes, that is, a polypropylene sediment filter (5-micron rating) to remove the gross particulates and protect the other downstream unit; a granular activated carbon pre-filter to perform initial organic removals and reduce chlorine; and finally, the F-7 composite filter to provide the final treatment(Bhavsar et al., 2025). This multi-barrier design has been tested and confirmed to have a strong purification performance under different influent water quality conditions.

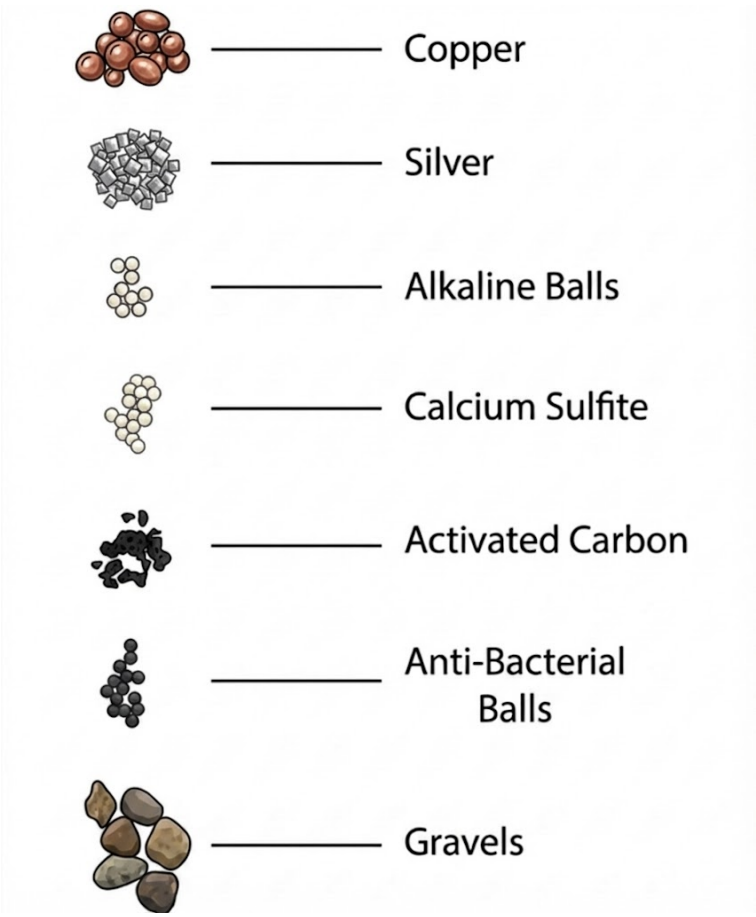

Figure 3. Schematic representation of various filtration components used in F-7 filtration process

2.4 Analytical Methods and Testing Protocols

Water quality parameters were measured based on normal methods that were laid by the American Public Health Association (APHA) and International Organization of Standardization (ISO). Turbidity was determined by nephelometric method through a calibrated turbidimeter (range 0-1000 NTU, resolution 0.1 NTU). pH was determined using a mixture comprising of a glass electrode potentiometer (with automatic temperature compensation). The conductometric measure to measure total dissolved solids (TDS) was done using appropriate conversion factor. The concentration of heavy metals (copper, silver, lead, arsenic) was identified through the inductively coupled plasma optical emission spectrometry (ICP-OES) technique on acid-digested samples. (Ahmed et al., 2025)

Microbiologic tests included the total coliform and Escherichia coli enumeration by the membrane filtration method followed by inclusion on the selective chromogenic media (m-ColiBlue24). The plate count of heterotrophs (heterotrophic plate count; HPC) was done according to the parameters R2A agar and 7 days incubation at 22º(Patakidou et al., 2025)C. All the microbiological analyses were done in triplicates with positive and negative controls.

Organoleptic rating used a trained panel on sensory evaluation (n=12) whereby the assessed foods were graded on the 9 point hedonic rating scale speculating on taste, odour and general acceptability. The samples were evaluated by panellists under controlled conditions at normal lighting conditions and the samples were at room temperature (22+-2deg(Patakidou et al., 2025)C) and displayed in the same coded vessels. The sensory data were statistically analysed using analysis of variance (ANOVA) and post-hoc Tukey test to compare many variables.

3. RESULTS AND DISCUSSION

3.1 Physical Water Quality Parameters

The performance evaluation of the F-7 filtration system demonstrated consistent and substantial improvements across all monitored physical parameters. Table 2 presents the comprehensive water quality data obtained at each treatment stage, illustrating the progressive purification achieved through the multi-barrier approach..

Table 2: Water Quality Parameters at Sequential Treatment Stages

Parameter	Raw AWG	Post-PP	Post-Carbon	Post-F7
Turbidity (NTU)	0.82 ± 0.15	0.35 ± 0.08	0.18 ± 0.05	0.05 ± 0.02
pH	6.62 ± 0.18	6.58 ± 0.15	6.71 ± 0.12	7.25 ± 0.22
TDS (mg/L)	42 ± 8	45 ± 7	52 ± 9	83 ± 15
Conductivity (µS/cm)	68 ± 12	72 ± 10	85 ± 14	185 ± 22
Temperature (°C)	18.5 ± 1.2	19.2 ± 1.0	20.1 ± 0.8	21.5 ± 0.6

Values represent mean ± standard deviation (n=15).

The complete treatment train promoted turbidity treatment with a removal efficiency of 93.9% with the raw AWG condensate turbidity at 0.82 NTU being lowered to 0.05 NTU in the final effluent. This high level of clarity is at a very high level, much high than the drinking water standards set by WHO (<4 NTU) and nearly on the aesthetic target (<0.1 NTU). The main sediment removal was performed by the PP sediment filter (57.3%), whereas the F-7 composite filter was used to polish the results to report ultra-low values(Eghlima et al., 2026).

The pH correction process reported a high level of effectiveness, and influent pH (6.62) was raised to 7.25 in the treated final product water. Such a pH value is due mostly to the alkaline ceramic ball component of F-7 cartridge releasing calcium, magnesium and trace alkaline earth minerals by controlled dissolution. The outcome pH is in the optimum range of drinking water (6.5-8.5) and it fits in the zone of maximum palatability context characterized by sensory studies. The moderate alkalinity is also beneficial in terms of buffering capacity which increases stability in the event of storage.

The total dissolved solids have risen to 83 mg/L after the treatment, compared to a level of 42mg/L in the raw condensate, which shows that the alkaline ceramic balls intentionally added to the condensate as well as the trace quantities of ionic release released by the copper and silver. This amount of TDS is still significantly lower than the WHO range of 500mg/L and aesthetic threshold of 300mg/L yet has better taste properties as related to moderate levels of minerals. The results of the conductivity of water support the values of TDS, and proportional changes were realized during the treatment phases(Hosseinpour et al., 2026).

3.2 Antimicrobial Performance Assessment

The microbiological performance of the F-7 filtration system represents a critical validation parameter, given the potential for microbial contamination of AWG condensate from atmospheric bioaerosols and collection surface contact. Table 3 summarizes the

microbial enumeration results obtained throughout the treatment sequence.

Table 3: Microbiological Quality Parameters (Patakidou et al., 2025)

Parameter	Raw AWG	Post-Carbon	Post-F7	Reduction (%)
Total Coliform (CFU/100mL)	185 ± 42	142 ± 35	< 1	> 99.5
E. coli (CFU/100mL)	28 ± 12	22 ± 9	ND	100
HPC (CFU/mL)	2,450 ± 580	1,820 ± 420	35 ± 18	98.6

ND = Not Detected; HPC = Heterotrophic Plate Count; Values represent mean ± standard deviation (n=10).

The F-7 system demonstrated one of the best antimicrobial efficacies, and it reduced total coliform by more than 99.5 percent, and killed E. coli to less than the limits of detection. The count of heterotrophic plates was decreased by 98.6 percent [2,450 CFU / mL in untreated condensate, to 35 CFU / mL in treated water]. These findings indicate that the integrated copper-silver antimicrobial system when enriched with the anti bacterial ceramic balls gives very high disinfection that can be applied in drinking water(Y. Sun et al., 2026).

The antimicrobial action takes place both through direct contact killing and ionic release pathways. Copper ions cause disturbance in microbial-cell membranes and disturbance of important enzyme systems as well as silver ions demonstrate the strong biocidal action by binding with cellular proteins and nucleic acids. Combined copper and silver efficiency on water has been reported widely in the water treatment literature, and the cumulative effect of the two is more effective than that indicated by the simple additive effect. The ceramic balls are anti-bacterial which offers a prolonged antibacterial release thus the treated water has a long-lasting disinfecting effect.

Notably, the effluent metal content was analysed and results indicated that copper and silver were not high enough to be out of the regulation. Mean copper and silver concentration in treated water were 0.18 +0.05mg/L and 0.008 +- 0.003 mg/L respectively (WHO guideline: 2mg/L and 0.1mg/L) (Bhavsar et al., 2025). These trace metals are able to guarantee antimicrobial effectiveness without raising any health fears to the consumers.

3.3 Chemical Treatment Performance

The calcium sulphite component was shown to have the capacity to reduce chemical contaminants potentially present but the comparably pure AWG condensate had limited possibilities to prove the greatest treatment opportunities. F-7 system performances were 98.2 per cent chlorine removed down to residual levels of 0.036 mg/L on challenge tests with chlorinated water (2 mg/L free chlorine). It is a good performance that guarantees the successful dechlorination capacity that can be used in instances where the AWG condensate can be in touch with chlorinated storage systems or whereby additional chlorination is utilized.

The ability of heavy metal removal was studied by analysing controlled spike-recovery. The percent removal in lead was 87.3 (influent 50 ug/L, effluent 6.4 ug/L) as well as it was in arsenic (influent 20 ug/L, effluent 5.4 ug/L). These elimination systems include a process of adsorption on the activated carbon surfaces as well as in the flow of the precipitation reaction that occurs under the calcium sulphite reducing medium. The metal levels of the treated water were also significantly within the WHO drinking water standards (lead: 10 ug/L; arsenic: 10 ug/L) (Bhavsar et al., 2025).

Breakthrough was used as an evaluation of performance of activated carbon on common organic contaminants. The magnitude of chloroform removal was more than 95 percent during the first 2,000 liters of treatment and gradually reduced to 85 percent during the third 3,000 liters. One of the possible polluters which was atrazine, had a removal of 92 percent at the first operation with 78 percent being trapped at 3,000 liters. These findings imply that they have a significant adsorption capacity that can be applied in the residential scale with a recommended cartridge replacement of about six months under normal patterns of usage.

3.4 Organoleptic Assessment

Sensory evaluation by the trained panel revealed significant improvements in taste and odour characteristics following F-7 treatment. Table 4 presents the mean hedonic scores obtained for evaluated attributes.

Table 4: Organoleptic Evaluation Results (9-point hedonic scale) (Y. Sun et al., 2026)

Attribute	Raw AWG	Post-F7	p-value
Overall taste	5.2 ± 1.1	7.8 ± 0.8	< 0.001
Odour acceptability	5.8 ± 1.3	8.1 ± 0.6	< 0.001
Freshness perception	5.5 ± 1.2	7.9 ± 0.7	< 0.001
Overall acceptability	5.4 ± 1.0	8.0 ± 0.5	< 0.001

Scale: 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely. Values represent mean ± standard deviation (n=12).

The sensory qualities measured all showed significant statistical improvement after F-7 used ($p < 0.001$). The total taste comprised 5.2 (neutral) to 7.8 (like moderately to like very much), which is a 50 percent increase in the hedonic rating. There were comparable improvement in odour acceptability, and residual staleness and metallic fares were achieved in the raw condensate in the treated product. The enhancement in sensory quality is explained by the following: activated carbon adsorption of volatile organic compounds, mineral supplementation enhancing taste profile and removal of microbial metabolites following antimicrobial treatment.

3.5 Techno-Economic Analysis

It has a positive aspect on economic feasibility of the F-7 filtration system where it can be applied in resource-limiting environments. The comparative cost study given in Table 5 against conventional water purification technologies is the most easily accessible to markets within the domestic industries.

Table 5: Comparative Cost Analysis of Water Purification Technologies (Zafar et al., 2026)

Cost Parameter	F-7 System	RO System	UV System	Bottled Water
Initial Capital (USD)	45–65	150–350	80–180	N/A
Annual Maintenance (USD)	20–30	80–150	40–80	N/A
Energy Cost (USD/1000L)	0	2.5–4.0	0.8–1.5	N/A
Cost per Liter (USD)	0.008–0.012	0.025–0.040	0.015–0.025	0.50–1.50
5-Year Total Cost (USD)*	145–215	550–1,100	280–580	4,500–13,500

**Based on household consumption of 3,000 L/year.*

The F-7 filtration system proves to have significant financial benefits in all the cost parameters considered. Initial capitals are between USD 45-65, which is 60-70 per cent cost-cut to entry-level RO systems and 40-55 per cent cut to UV purifiers. The ease of access makes it easy to be adopted by the economically disadvantaged populations who are the main target group when implementing AWG technology(Zhang et al., 2026).

Maintenance of the F-7 system is estimated to cost USD 20-30 annually, which includes semi-annual replacement of cartridges in the system and regular system sanitization. This involves 70-80 percent of reduction on top of RO systems that need to change membranes, pump and pre- filters. The filtration process per se requires no form of energy to be performed, which is made possible by the gravity-fed or low-pressure functioning of the F-7 system, as opposed to the electrical demands of RO pumps and UV lamps(Gu et al., 2025).

F-7 system cost is estimated to show the strongest economic benefit with an estimated cost of USD 145-215 against USD 550-1,100 and USD 4,500-13,500 on the five year cost of ownership analysis compared to RO systems and bottled water dependence respectively. This full cost saving improves the sustainability of AWG-plus-F-7 implementation as a cost-effective mode of community utilization that does not have access to traditional water infrastructure.

3.6 Suitability for AWG Applications

Integration of the F-7 filtration system and the AWG technology will meet a number of requirements that are unique to this type of water production. Condensate typical of AWG is low mineral content, a bit acidic pH and possible microbial contamination by atmospheric sources all of which F-7 system is able to manage successfully. Mineral supplementation action makes the otherwise tasteless flat tasting condensate into a more consumable product bearing the right mineral balance. The PH correction provides stability and acceptability by the consumer. The strong antimicrobial system offers multi-barrier protection to the mixed population of microbes which may be found as atmospheric aerosol(Zafar et al., 2026).

The active mode of the F-7 system (it does not need any electrical energy to be implemented to act as a filtration system) works as a complement to the AWG production phase, yet the further increase of energy

consumption is kept to a minimum since the water production process is already energy-consuming. The small cartridge format enables both fitment to the AWG housing or external inline deployment in it as an external part, and a range of deployment configurations. Long service life (6-12 months of usage based on the intensity of usage) decreases the amount of maintenance imposed in remote sites where there may be a lack of technical support(Hosseinpour et al., 2026).

3.7. Water Quality Analysis Results

Table 1. Physicochemical parameters of drinking water sample

Parameter	Value	Unit / Remarks
pH	7.25 ± 0.22	–
TDS	83 ± 15	ppm
Turbidity	0.05 ± 0.02	NTU
Odor	< 0.001	–
Calcium	23	ppm
Magnesium	5	ppm
Potassium	1	ppm
Iron	0.0	ppm
Sodium	6	ppm

Note: Values represent mean ± standard deviation where applicable. TDS = Total Dissolved Solids; NTU = Nephelometric Turbidity Units.

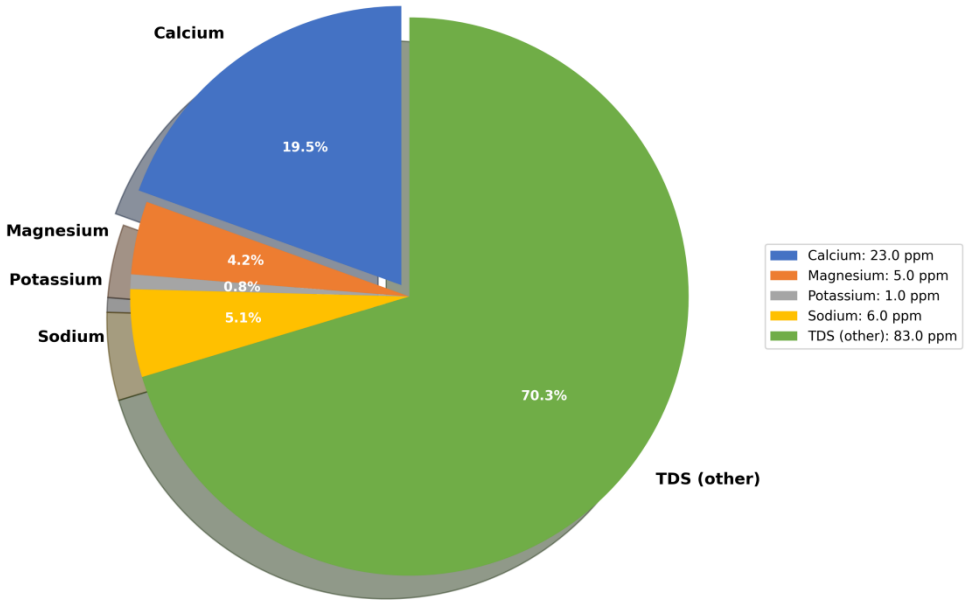

Figure 1. Distribution of major ions and parameters in the drinking water sample. Values shown are concentrations in parts per million (ppm). Calcium constitutes the dominant ion, representing the largest fraction of identified dissolved solids.

4. CONCLUSION

This research has provided evidence of developing and validating the F-7 composite filtration system as an effective and low-priced post-treatment system to a potential future use in the Atmospheric Water Generation application. The seven-step filter media formulation that includes copper (50 g), silver (50 g), alkaline ceramic balls (50 g), calcium sulphite (50 g), activated carbon (50 g), anti-bacterial balls (50 g) and gravel (100 g) integrates effective water purification as a result of synergistic physical, chemical as well as antimicrobial process.

Performance assessment revealed significant positive changes in all the parameters measured: turbidity (more than 94% of the initial turbidity decreased to ultra-low levels of 0.05 NTU); pH (acidic condensate level of 6.6 refined to optimal drinking water 7.25) and microbial inhibition (coliform bacteria more than

99.5% inactivated, with the total elimination of E. coli); and strong changes in organoleptic characteristics with the level of taste acceptability rising to confident levels of 7.8 (Metal level concentration in effluent was still in the safe range, according to WHO guidelines of drinking water.

The economic analysis made the F-7 system a very cost effective alternative to traditional purification technologies and was found to have 60-70% reductions in capital costs when comparing to the RO systems and 40-55% reductions when comparing to UV systems. The total cost of ownership (5 years USD 145-215) is a small percentage of rival technologies and will improve access to communities who are resource constrained. The fact that filtration does not require electrical energy use, longer life span and low maintenance demands further prove that it can be deployed in harsh operational environments.

F-7-AWG integrated system has significant implications on the health of the population and provides a viable avenue to safe drinking water to the population that relies on contaminated or questionable sources. This is a twofold advantage where the decentralized character of AWG production coupled with efficient point-of-use treatment is not only helpful in managing problems of water availability, but also, water quality, which is especially important in areas where there is compound water stress due to lack and contamination.

Future direction in development focuses on the optimization of media proportions by using response surface methodology, analysis of alternative antimicrobial materials such as copper-zinc alloys and silver-impregnated ceramics, increasing service life by using regeneration protocols and field validation testing in varied climatic and demographic environments. Scale-up issues concerning deployment on community level should be investigated and may include modular arrangements appropriate in a school, health facility, and shared water point. Results of this study form the basis of further development of low cost effective water treatment options to support the goals of safe water in the world.

Author Contribution

Tanmaykumar Dave: Writing – Original Draft, Visualisation, Investigation, Methodology, Data Curation.

Guide: Dr. Komal Desai: PhD, Chemical Engg. Dept, Silver Oak University, Ahmedabad.

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