Air-Conditioners Condensate Water Collection and Its Uses for Domestic Purposes

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***Abstract*—Collection system of condensate AC water is reuseable, particularly for applications such as landscape, plant irrigation, swimming pools, spas, and public bathing facilities, thereby contributing to sustainable water resource management. Data collection involved condensate discharge measurements, field observations, and documentation. The findings revealed that condensate water produced by a air conditioner met the required physical and microbiological quality standards prescribed by different code of practices. The results indicate that, after appropriate treatment using filtration and UV disinfection, AC condensate has potential for uses of water in many operations like sanitation, swimming pools and Public Baths.**

***Index Terms*—Condensate water, remineralization, corrosion-resistant, centralized-collection, implementation-cost and collection network**

I. INTRODUCTION

Air conditioning (AC) systems generate a considerable amount of condensate water; however, this wastewater is generally discharged directly into the surrounding environment without any beneficial use. The study aimed is:

1. To quantify the volume of AC condensate produced over a 30-minute period and
2. To evaluate the effectiveness of a simple filtration system in improving the quality of AC wastewater for potential use in plant irrigation.
3. To quality analysis focused on parameters such as hardness, pH, and ammonia concentration.

The results indicate that, after appropriate treatment using filtration and UV disinfection, AC condensate has potential for reuse, particularly for applications such as landscape and plant irrigation, thereby contributing to sustainable water resource management. The study adopted a descriptive qualitative research design with an evaluation approach to determine both the quantity and the physical and microbiological characteristics of AC condensate. To improve water quality, a filtration unit consisting of a sponge and activated charcoal was employed. The sponge served to remove suspended solids, while activated charcoal prepared from inexpensive coconut shells was used to adsorb ammonia (NH_4^+) and other impurities. In addition, ultraviolet (UV) irradiation was applied as a disinfection method because of its effectiveness in destroying bacteria and other microorganisms without causing harmful environmental impacts. The results are comparable with the water quality standards.

II. METHODOLOGY

Water was collected and measured at every 30 minutes interval. This condensate after collection was tested for different physical and chemical properties. The equipment used includes a measuring jar, TDS meter, thermometer, turbidity meter, timer, sample bottles, Bunsen burner, alcohol, and an ice box for sample preservation. The temperature range was kept in the range of 18 degree centigrade to 25 degree centigrade. 5-20 gallons per day per ton of AC water is collected depending on the weather conditions. The main features to study are:

- To determine the quality standards of the air-conditioned water
- To analysis whether air-conditioned water is suitable for drinking purpose
- To determine how to harvest airconditioned water from the air conditioner through pipe
- To estimate the amount of water to be collected for the provided building per day
- To reduce the consumption of ground water usage
- To design the plumping layout for the collection of air-conditioned water.

III. AC RREQUIRED FOR COLLECTION OF CONDENSED WATER

There is no fixed minimum number of air-conditioning units for which an AC condensate water collection system is mandatory. The decision is generally based on the quantity of condensate water generated, the economic feasibility, and the intended reuse of the collected water.

For practical implementation, the following guidelines are commonly adopted are provided in table 1

Table 1

Number of AC Units	Recommendation	Remarks
1–5 units	Generally, not recommended	Low condensate yield; collection cost is usually not justified.
6–10 units	Can be considered	Suitable if the units are located close together and water is required for gardening or cleaning.
11–20 units	Recommended	Economically viable for offices, schools, and small commercial buildings.
More than 20 units	Strongly recommended	High water recovery potential; suitable for centralized collection and reuse.

IV. LITERATURE REVIEW

Air conditioners normally produce condensate water as part of the cooling process. Under typical operating conditions, an air conditioning unit may discharge approximately 5–20 gallons (19–76 litres) of condensate per day through the condensate drain, depending on factors such as humidity, operating time, and system capacity. The discharge of condensate water through the designated drain line outside the building is considered normal, whereas water leakage inside the building, particularly around the indoor unit, indicates improper drainage or a malfunction in the condensate disposal system.

Studies conducted in India have shown that AC condensate water is generally of high purity, exhibiting characteristics similar to distilled water with low Total Dissolved Solids (TDS). Because of its relatively good quality, this water has significant potential for non-potable applications, including landscape irrigation, gardening, toilet flushing, vehicle washing, and make-up water for cooling towers after appropriate filtration. Some researchers have also reported that, following suitable treatment, including remineralization and disinfection, AC condensate can meet drinking water quality standards. However, the water may contain dissolved carbon dioxide, resulting in slightly acidic pH, and may also harbour non-pathogenic microorganisms if not collected and stored properly. Therefore, appropriate collection, storage, filtration, and disinfection systems are recommended to preserve water quality and ensure safe reuse. Unlike treated municipal wastewater, which is governed by specific reuse standards, AC condensate generally requires only minimal treatment due to its inherently low contaminant levels, making it an attractive alternative water source for sustainable water management.

Air conditioner (AC) condensate is produced through the condensation of atmospheric moisture on the evaporator coil and is generally regarded as a high-purity water source. Due to the condensation process, the water contains very low concentrations of dissolved salts and suspended solids, giving it characteristics similar to distilled water. This makes AC condensate suitable for a variety of non-potable applications, including landscape irrigation, toilet flushing, cooling tower make-up water, battery maintenance, and other industrial processes that require low-mineral-content water.

Several studies conducted in India and other countries have reported that the physicochemical characteristics of AC condensate, including pH, Total Dissolved

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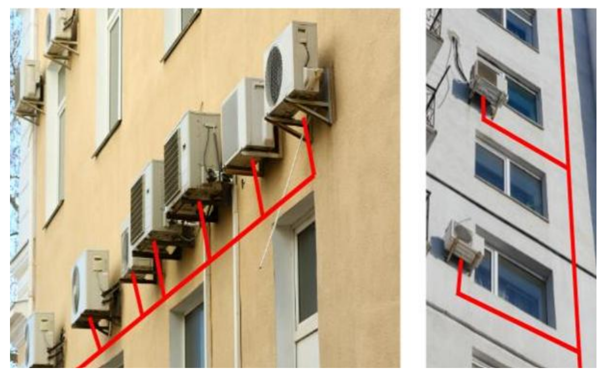
Solids (TDS), Chemical Oxygen Demand (COD), and heavy metal concentrations, generally fall within acceptable limits for reuse in irrigation, domestic, and industrial applications. With appropriate treatment, such as filtration, disinfection, and remineralization, AC condensate may also be considered for potable purposes where permitted by local regulations.

From a microbiological perspective, freshly generated AC condensate typically contains low bacterial concentrations, and the microorganisms present are generally non-pathogenic. However, contamination can occur during collection and storage; therefore, proper handling, storage, and periodic disinfection are essential to maintain water quality. The water may also exhibit a slightly acidic pH because of dissolved carbon dioxide (CO_2), although this characteristic can be corrected through simple treatment methods when necessary.

The quantity of condensate generated is substantial and depends on factors such as air conditioner capacity, ambient temperature, relative humidity, and operating duration. Under typical climatic conditions, a single air conditioning unit can produce approximately 15–70 litres of condensate per day, representing a valuable alternative water resource that can contribute to water conservation and sustainable water management.

Although AC condensate is not classified as treated wastewater, its quality can be evaluated by comparing it with relevant Indian water quality standards. According to IS 1172 (Code of Basic Requirements for Water Supply, Drainage and Sanitation) and IS 2490 (Tolerance Limits for Industrial Effluents), the acceptable pH range for general water reuse is typically 5.5–9.0. In comparison, AC condensate generally exhibits very low Total Dissolved Solids (TDS) and negligible Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), indicating minimal organic and inorganic contamination. These characteristics demonstrate that AC condensate is a relatively clean water source that requires only limited treatment before reuse in suitable non-potable applications.

AC Condensed water collection System Image 1



AC Condensed water collection System Image 2

V. OPERATIONS INVOLVED FOR COLLECTION CONDENSED WATER

a) Condensate Drain Outlet
- Each indoor AC unit is connected to a drain pipe.
- Condensate flows by gravity from the drain pan.

b) Branch Pipes
- Individual PVC pipes (20–25 mm diameter) collect water from each AC unit.
- Pipes are laid with a slope of 1–2% toward the main drain.

c) Main Collection Pipe
- Receives condensate from all branch pipes.
- Pipe diameter is selected based on the total discharge (typically 40–75 mm for medium-sized buildings).

d) Clean-Out/Inspection Points
- Installed at regular intervals and at changes in direction.
- Facilitate cleaning and maintenance.
- Filter or Debris Trap

- Removes dust, algae, and other suspended particles before storage.

e) Storage Tank

- Collects condensate water.
- Equipped with overflow, vent, and drain arrangements.

f) Distribution System

- A small pump may be provided to reuse stored water for:
- Toilet flushing
- Landscape irrigation
- Cooling tower makeup
- Cleaning and washing

VI. DESIGN CONSIDERATIONS

- Use uPVC or CPVC pipes that are corrosion-resistant.
- Maintain a minimum slope of 1–2% for gravity flow.
- Avoid sharp bends to prevent clogging.
- Provide pipe supports at appropriate intervals.
- Install P-traps where required to prevent odor or air leakage.
- Insulate pipes in humid areas to prevent external condensation.
- Design storage capacity based on expected condensate generation and daily water demand.
- Ensure overflow is connected to a rainwater drain or recharge pit.

VII. ADVANTAGES

- Conserves potable water.
- Reduces discharge into stormwater drains.
- Lowers building water consumption.
- Supports sustainable and green building practices.
- Reduces operating costs by providing an alternative water source for non-potable applications.

This type of collection network is suitable for office buildings, educational institutions, hospitals, hotels, shopping malls, and other commercial buildings where numerous air-conditioning units generate a significant volume of condensate water. Result Analysis Summary is shown in table 2.

Table 2

S. No	Parameter	Permissible limits	Result	Protocol
1.	pH@25°C	6.5-8.5	7.41	IS:3025:part:11-1983(reaf f:2012)
2.	Colour	5-50 Hazen	5 Hazen	IS:3025:part:4-1983(reaf f:2012)
3.	Colour	Agreeable	Agreeable	IS:3025:part:5-1983(reaf f:2012)
4.	Electrical Conductivity @25°c	0.4-0.85 m moles/cm	70.3µmhos/cm	IS:3025:part:14-2013
5.	Total hardness as caco3	300-600mg/l	BDL(DL:1.0mg/l)	IS:3025:part:21-2009(ref 2014)
6.	Calcium hardness as CaCO3	100-400 mg/l	BDL(DL:1.0mg/l)	IS:3025:part:21-2009(ref 2014)
7.	Magnesium hardness as caco3		BDL(DL:1.0mg/l)	IS:3025:part:21-2009(ref 2014)
8.	Total alkalinity as CaCO3	80-120 mg/l	23mg/l	IS:3025:part:23-1986(ref 2014)
9.	Phenolphthalein alkalinity CaCO3	Depend upon Co2	Nil	IS:3025:part:23-1986(ref 2014)
10.	Chloride as cl	250-1000 mg/l	3.9mg/l	IS:3025:part:32-1988(ref 2014)
11.	Sulphate as SO4	150-200 mg/l	BDL(DL:1.0mg/l)	IS:3025:part:24-

				1986(ref 2014)
12.	Acidity		6.9mg/l	IS:3025:part:22-1986(ref 2014)
13.	Dissolved oxygen	500 mg/l	6.4mg/l	IS:3025:part:38-1989(ref 2014)
14.	Iron as Fe	0.3-1 mg/l	BDL(DL:0.01mg/l)	IS:3025:part:53-2003(ref 2014)
15.	Fluoride as F	0.6-1.2 mg/l	BDL(DL:0.1mg/l)	APHA-22nd Edn 2012-4500F,D
16.	Phosphate as P	0.03-0.2 mg/l	BDL(DL:0.01mg/l)	IS:3025:part:31-1988 (ref 2014)
17.	Ammonium nitrogen as N		BDL(DL:1 mg/l)	IS:3025:part:34-1988 (ref 2014)
18.	Calcium as Ca	75-200 mg/l	BDL(DL:1 mg/l)	IS:3025:part:40-1991 (ref 2014)
19.	Magnesium as Mg	30-100 mg/l	BDL(DL:1 mg/l)	IS:3025:part:46-1994 (ref 2014)
20.	Anionic surface active agent as (MBAS)	0.2-1 mg/l	BDL(DL:0.01mg/l)	S:13428-2005(reaf f:2014)
21.	Non carbonate hardness as CaCO3		Nil	S:3025:part:21-2009 (ref 2014)
22.	carbonate hardness as CaCO3		Nil	S:3025:part:21-2009 (ref 2014)
23.	Sodium as Na	< 100 mg/l	BDL(DL:0.5mg/l)	IS:3025:part:45-1993 (ref 2014)
24.	Copper as Cu	0.05-1.5 mg/l	BDL(DL:0.02mg/l)	IS:3025:part 65:2014
25.	Zinc as Zn	5-10 mg/l	BDL(DL:0.05mg/l)	IS:3025:part 65:2014
26.	Aluminium as Al	0.05-0.2 mg/l	BDL(DL:0.02mg/l)	IS:3025:part 65:2014
27.	Escherichia coli	Not acceptable	Absent/100ml	IS:1622:1981(reaf f:2009)
28.	Total coliform	Not acceptable	Absent/100ml	IS:1622:1981(reaf f:2009)
Note: BDL: Below Detection limit DL: Detection limit				

VIII. PRECAUTIONS NEEDED FOR ADOPTING SYSTEM

Proper installation of an AC condensate water collection system is essential to ensure efficient operation, prevent water leakage, and maintain water quality. The following precautions should be observed during design and installation

a) Proper Pipe Slope
- Maintain a continuous downward slope of 1–2% (10–20 mm per metre) to ensure gravity flow.
- Avoid flat or reverse slopes, which can cause water stagnation and overflow.

b) Appropriate Pipe Size
- Select pipe diameters based on the expected condensate flow from all connected AC units.
- Undersized pipes may overflow, while oversized pipes may allow sediment accumulation.

c) Use Corrosion-Resistant Materials
- Use uPVC, CPVC, or HDPE pipes that are resistant to corrosion and biological growth.
- Avoid materials that may rust or contaminate the collected water.

d) Leak-Proof Joints

- Ensure all pipe joints are properly sealed using approved fittings and solvent cement.
- Conduct a leak test before commissioning the system.

e) Adequate Pipe Support
- Support horizontal pipes at regular intervals to prevent sagging.
- Secure vertical pipes firmly to avoid movement due to vibration.

f) Install Clean-Outs and Access Points
- Provide inspection openings at suitable intervals and at changes in direction.
- Ensure easy access for periodic cleaning and maintenance.

g) Proper Trap Installation
- Install P-traps or U-traps where required to prevent air leakage, unpleasant odours, and insect entry.
- Ensure trap seals are maintained.

h) Prevent Blockages
- Install strainers or debris filters at suitable locations.
- Avoid sharp bends and unnecessary fittings that may trap dirt.

i) Water Quality Protection
- Keep the collection system closed to prevent contamination from dust, insects, and debris.
- Clean storage tanks and filters regularly.

j) Storage Tank Precautions
- Use a covered storage tank to prevent algal growth and mosquito breeding.
- Provide overflow, vent, drain valve, and access for cleaning.
- Ensure proper ventilation without allowing contamination.

k) Overflow Arrangement
- Connect overflow pipes to the stormwater drainage system or a groundwater recharge structure.
- Ensure overflow does not cause waterlogging around the building.

l) Avoid Cross-Connection
- Do not connect condensate pipes with sewage, wastewater, or drinking water pipelines.
- Clearly identify condensate collection pipes to prevent accidental cross-connections.

m) Protect Against Freezing (Cold Regions)
- In cold climates, insulate exposed pipes or provide freeze protection to prevent blockage.

n) Structural Safety
- Avoid drilling or damaging structural members while routing pipes.
- Ensure proper supports are provided for overhead piping.

o) Accessibility for Maintenance
- Design the network so that all filters, valves, and storage tanks can be easily inspected and cleaned.

p) Pump Installation (If Required)
- Install a condensate pump only where gravity drainage is not feasible.
- Provide automatic level controls and a backup power supply if continuous operation is critical.

q) Regular Inspection and Maintenance
- Inspect pipes periodically for leaks, blockages, algae, and sediment.
- Clean filters and storage tanks at regular intervals.
- Check pipe supports and joints for deterioration.

r) Compliance with Standards
- Follow applicable IS codes, the National Building Code (NBC) of India, HVAC installation guidelines, and local plumbing regulations.
- Ensure the collected condensate water is used only for non-potable purposes (e.g., toilet flushing, irrigation, cooling tower makeup, and cleaning) unless it is treated and tested to meet potable water quality standards.

IX. SUMMARY

By following these precautions, an AC condensate water collection system will:
- Operate efficiently with minimal maintenance.
- Prevent leakage, blockage, and overflow.
- Maintain the quality of collected condensate water.
- Increase the service life of the piping system.
- Contribute to sustainable water conservation in residential, commercial, and institutional buildings.

X. CONCLUSION

Water is an essential natural resource and a fundamental requirement for sustaining life; however, increasing water scarcity and declining water quality have become major global concerns. This study investigates the potential of air conditioner (AC) condensate as an alternative source of water. The condensate collected from AC units was analysed for various physicochemical parameters and was found to comply with the relevant Indian standards for potable water quality. Furthermore, the study estimated the implementation cost of a condensate water harvesting system for an office building and developed a collection network layout to facilitate efficient water recovery. The findings indicate that the adoption of such a system can provide a sustainable supplementary water source, reduce the wastage of condensate water, and contribute to mitigating water scarcity, particularly in commercial and institutional buildings.

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