Air Conditioning Condensate: A Potential Water Source and a Creeping Destroyer

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Abstract. This study determines air conditioning condensate a potential alternative water source, its implication and possible applications. Outdoor and indoor air temperatures and relative humidity were directly measured using a digital RH anemometer pen and a 0.75 hp Window-type Air Conditioner was utilized in the microclimate room. Using this type of air conditioner with occupants in the space at high cool setting collected 25.92 to 36.72 liters of condensate water per day. The condensate water is clear with very little to no suspended solids and the water has an 8.6 pH and considered at basic level. Air conditioning condensate is a potential alternative water source when properly collected for non potable uses and the non removal of condensate water from the air conditioning unit can cause harmful effects to the occupants and further cause damage to the equipment and building structure.

1. Introduction

Over the past decades it has gradually become evident that water crisis is continuously threatening the world and the Philippines has experienced this silent crisis that it is a nest of problems that affect our quest towards sustainable development [3]. Environmental laws were created to further protect the country's water resources linked to attain the goals focusing on energy, food security and mitigation of disaster due to natural and man made calamities.

A water crisis is already felt among families who do not have access to safe drinking water and also do not have sanitary comfort rooms [2]. Water conservation, effective water harvesting and recovery measures offer appropriate and possible solutions to the water crisis. First world countries like the United States and Europe are taking the water crisis seriously that water conservation policies were created and implemented to address the issue towards sustainability [2].

Looking beyond water conservation at alternative water resources is necessary to help solve the potential water shortages. The alternative water sources available are gray-water, rooftop rainwater, landscape-scale stormwater, air conditioner condensate, mechanical equipment blow-down, wastewater and desalinated water [4]. Rainwater harvesting is not new but centuries-old technology which provide an easy way of collecting water for several uses.

In a direct-expansion (DX) coil, the refrigerant (usually HCFC-22, HFC134a, HFC-404A, HFC-410A, HFC-407A or HFC-407C) is evaporated and expanded directly inside the tubes to cool and dehumidify the air flowing it, and condensation occurs on the outer surface of the DX coil which also acts as the evaporator in a refrigerating systems [6].

Air blowing past the coils cools off as it goes by, and the moisture from the air condenses on the coils. Condensate production is a function of the temperature and relative humidity of the outdoor air, the target conditions in the space (temperature and relative humidity), and the amount of cooling that is provided in the space.

The Philippines has a tropical maritime climate and is usually hot and humid. There are three seasons: the hot dry season or summer, the rainy season, the cool dry season . Temperatures usually range from 21°C (70°F) to 32°C (90°F) although it can get cooler or hotter depending on the season. The average yearly temperature is around 26.6°C (79.88°F).

In this type of climate, in fast growing urban areas, air conditioners abound in hotels, school buildings, shopping malls, condominiums and high rise buildings. In most cases, condensates from air conditioning drains carry away the water, usually into the sewer. Instead of wasting it, recovery of air conditioner condensate is being considered in this study to determine its potential as an alternative water source, its implication and possible applications.

2. Material and Methods

The study was conducted in the microclimate room at the Mechanical Engineering Laboratory of the Mechanical Engineering Department, College of Engineering, University of San Carlos, Cebu City, Philippines. The materials used in this study consist of a 5 gallon container, ½ inch plastic tubing length will vary depending on location of the AC unit, distilled water, funnel, beakers, graduated cylinder, pH test calibrating and soaking solutions, detergent, rubber gloves, paper towels, calculator, digital pH meter, digital RH Anemometer pen, and timer.

A 0.75 hp capacity window-type air conditioner (AC) is mounted on the upper right portion of the room with transparent condensate drain pipe attached to the lower portion of the condensate catch pan as shown in Figure 1. The window-type air conditioner was mounted about five feet above the floor, in the wall at the left portion of the aluminum automatic swing door of the micro climate room referred to as the air conditioned space as shown in Figure 1. The microclimate room was constructed inside the Mechanical Engineering Laboratory. It was made of ¾ inch thick marine plywood bolted and fastened in angular bar frames measuring 4m x 4m x 4m. The cubicle space was properly insulated and sealed to minimize infiltration of air into the air conditioned space.

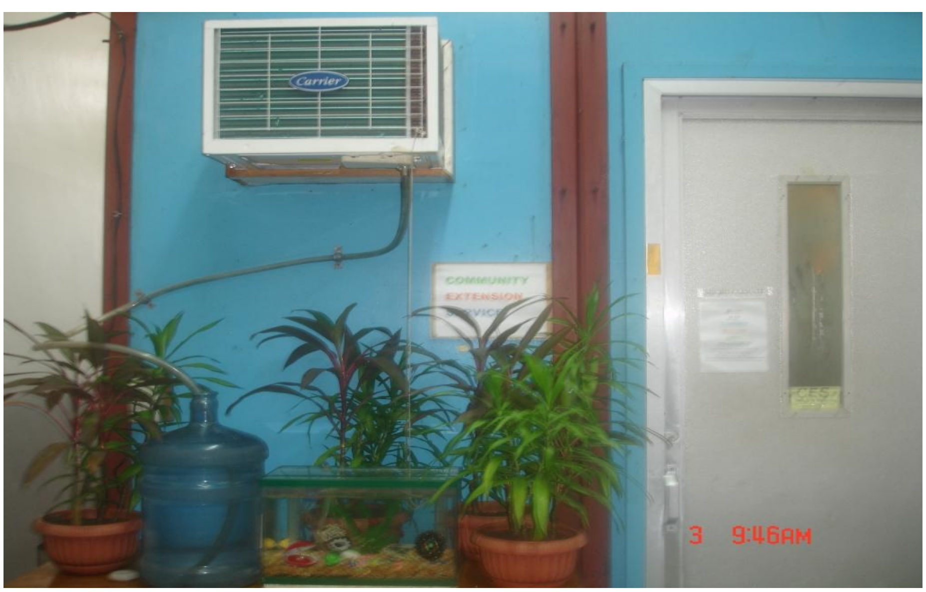

Fig. 1. Microclimate Room

Prior to the experimental runs, the materials for the AC and apparatus were set up. The start time, temperature of the AC setting, out door temperature and humidity were recorded. Condensates were collected right after recording the stop time, temperature of the AC setting, out door temperature and humidity. The pH meter used to determine the condensates pH level provides a value as to how acidic or alkaline a liquid is. The basic principle of the pH meter is to measure the concentration of hydrogen ions. Acids dissolve in water forming positively charged hydrogen ions (H+). The greater this concentration of hydrogen ions, the stronger the acid is. A graduated cylinder was used to determine the volume of the condensate collected during the particular run and the pH level of condensate was also measured using the pH meter as shown in Figure 2.

Fig. 2. Measurement of pH level

2.1 Results and Discussions

Condensate Production

Moisture in air was removed and forms condensate on the outer surface of the DX coil. The amount of air conditioner condensate that was produced is a function on the interior relative humidity and temperature load. The interior relative humidity is related to the exterior absolute humidity (which is high during summer) and the interior moisture load. Large amounts of air conditioner condensates are produced in high occupancy buildings like office buildings, schools, malls and hotels.

2.2 Experimental Results:

In this study, experimental runs were conducted where the microclimate room has no occupant and with occupants. Table 1 shows the results, where the microclimate room has no occupant. Using the AC window type ¾ hp-capacity at high cool setting, with outdoor conditions 24.4 ^{o}C, 86.7 % RH, inside conditions 22.8 ^{o}C, 77 % RH, the rate of condensate collection was 0.56 liters/hr and the average condensate production was 0.53 liters/hr. Lower outdoor temperature was experienced since it was a rainy day when the experiment was conducted. The colder the air the less moisture it can hold and the warmer the air the more moisture it can hold.

Table 1. Condensate Production Rate

No. of Occupants: 0					Condensate
Run	Outside Conditions		Inside Conditions		liters/hr
	ºC	% RH	ºC	% RH	
1	24.4	86.7	22.8	77	0.56
2	24.4	89.9	21.9	71.4	0.57
3	24.9	85.4	21.3	70.7	0.45
Average Amount					0.53

As shown in Table 2 the average condensate production was 1.24 liters/hr under high cool setting of the AC with nine (9) occupants, higher outside conditions of 31.5 ºC, and 68 % RH. The indoor condition was measured at 24.9 ºC, 54 % RH. The presence of occupants in the air conditioned space is a big factor that contributed to the in increase in condensate production as compared with no occupants at all.

Table 2. Condensate Production Rate

No. of Occupants: 9 persons					Condensate
Run	Outside Conditions		Inside Conditions		Liters/hr
	ºC	% RH	ºC	% RH	
1	31.5	68	24.9	54	1.31
2	31.0	73	23.9	55	1.34
3	30.3	77	23.5	56	1.08
Average Amount					1.24

Increasing the number of occupants in the same space with the same size of AC, the internal cooling load will increase since the sensible and latent heat load is directly proportional to the number of people in space [1]. With more than nine occupants in the room, the average condensate production rate was 1.41 liters/hr at higher temperature and relative humidity levels as shown in Table 3. Occupants were uncomfortable in this air conditioner setting.

Table 3. Condensate Production Rate

No. of Occupants: > 9 persons					Condensate
Run	Outside Conditions		Inside Conditions		liters/hr
	ºC	% RH	ºC	% RH	
1	30.8	69	26.0	47	1.53
2	30.5	74	24.0	56	1.44
3	30.0	75	23.0	62	1.26
Average Amount					1.41

2.3 Condensate Quality Analysis

In general, a water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The pH scale ranges from 0 to 14. The volume of condensate collected in all experimental runs was subjected to pH test using a digital pH meter and was found out to have a pH level of 8.60. Therefore, the water condensate collected is considered basic. The water produced from the AC condensate is clear with very little to no suspended solids.

2.3.1 Condensate Water Uses

Condensate water quality is basically the same as distilled water, mineral free and the near zero level of Total Dissolved Solids (TDS). Since it has low-mineral quality and lack of sanitizers like chlorine, chloromine makes it appropriate for irrigation purposes. This water may be used similar to collected rainwater like irrigation for plants not intended for human consumption in residential sectors.

In large commercial air conditioner, one of the best uses of condensate is make-up for the cooling tower. It may be possible to use condensate water for water cooled equipment, fountains and other water features, aquariums, evaporative coolers, washing vehicles, water for laundry operations and other industrial processes.

2.3.2 Air Conditioning Condensation Problems

Each time an air conditioner runs, it extracts moisture from the air inside the conditioned space. The water is usually drained outside the space through a condensation pipe. When there is no periodic maintenance of the pipeline, there is a possibility that the condensate line will clog up water spill into the unit causing rust formation and corrosion or may overflow into the ducting and can cause water damage to ceilings and walls. Condensate problems can lead to leaks into the building or space, growth of mold which is linked to the occupant's allergic reactions, asthma attacks, and hypersensitivity pneumonitis [6].

Pipes clog from scale and other solids building up in the pipeline and also the microbiological growth in pipes. Air conditioner condensate can damage built-up roofing when it contains many potentially damaging chemicals from additives used to control microbiological growth in catch pans [5]. The destructive elements present in condensate are copper ions, water and acid. The effect when this type of acidic condensate is continuously in contact with the roofing may result to early replacement of the roof because acid and copper ions will slowly breach the coating.

3. Conclusion

Based from the results, the air conditioning condensate production rate ranges from 25.92 to 36.72 liters of condensate water per day from a window-type air conditioner. The condensate water is clear with very little to no suspended solids and the water quality has an 8.6 pH level. Efficient collection of condensate from air conditioners makes it a potential alternative water source for non potable needs.

Poor preventive maintenance in condensate pipe lines and the non removal of condensate water from the air conditioning unit can cause harmful effects to the occupants due to microbiological growth which affect the indoor air quality of the space and also create a creeping destruction to the equipment and building structure.

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