USE OF PROCESSED INDOOR AIR CONDITIONING HUMIDITY AS UNCONVENTIONAL WATER RESOURCE

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ABSTRACT

Water scarcity becomes a topic of interest for everybody worldwide due to the increasing population which led to expanding human activities that affect both water quality and quantity. The problem is exacerbated and becomes more serious as a direct impact of the global climate change. It is therefore necessary to avail certain tools through research where a balance could be stroke between the demand and supply in view of the climate change. Other factor, that the global warming induces, is the increase of air temperature which consequently leads to magnify air humidity. Due to the anticipated global water shortage with respect to the demand increase, an attempt is being tried to develop additional supplementary water source which is the subject of the current study.

This piece of work identifies a possible source of additional water that people do not account for which can be obtained through the air conditioning process. The cooling mechanism of the air conditioners includes condensing the indoor humidity which is released through a rubber tube to sink. Rough estimate of the quantity of the distilled water revealed the possibility of producing two liters of water during one hour of continuous operation of an air conditioner. Consequently, if one million of air conditioners are simultaneously and continuously in operation for about 8 hours a day, an extra water of about 16,000 cubic meters can be attainable. It is supposed that the operation of these air conditions is during the summer season which is lasting for 120 days a year. Hence, the total anticipated amount of water that could be annually collected is 1,920,000 cubic meters. This amount of water may considerably be enhanced in the hot countries, namely Gulf countries where the period of air conditioner operation could be increased to about 16 hours per day for eight months per year. The anticipated amount would then be 7.68 m^3/year for every air conditioner and about 7.68 million cubic meters for one million air conditioners.

So far, two governing conditions should be fulfilled for successful use of this condensed water as an unconventional resource that are; the safe quality and economically viable to be applied. Therefore, this paper describes the adopted approach to check the water quality and the identification of employing such water. This includes description of water sampling technique and results of water quality analysis which are compared to the standards of drinking water. While as in order to assure the feasibility of such application, several ideas for employing the obtained water are recommended. This includes the design of collecting scheme that is described in this paper.

Keywords: Water Resources**,** Water Scarcity, water quality parameters, drinking water standards, irrigation water standards, Air conditioning.

INTRODUCTION

Water can be considered as the most essential tools for all socio-economic development and healthy ecosystems**.** As population increases and development calls for increased allocations of groundwater and surface water for the domestic, agriculture and industrial sectors, the pressure on water resources intensifies, leading to tensions, conflicts among users, and excessive pressure on the environment. The increasing stress on freshwater resources brought about by ever rising demand and profligate use, as well as by growing pollution worldwide, is of serious concern.

Inequity between availability and demand, the degradation of groundwater and surface water quality, intersectoral competition, interregional and international conflicts, all contributes to water scarcity.

Scarcity often has its roots in water shortage, and it is in the arid and semiarid regions affected by droughts and wide climate variability, combined with population growth and economic development, that the problems of water scarcity are most acute.

Water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. **By 2025, 1 800 million people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under stress conditions.** The situation will be exacerbated as rapidly growing urban areas place heavy pressure on neighboring water resources.

Addressing water scarcity requires actions at local, national and river basin levels. It also calls for actions at global and international levels, leading to increased collaboration between nations on shared management of water resources (rivers, lakes and aquifers), it requires an intersectoral and multidisciplinary approach to managing water resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

It is probably in rural areas that water scarcity affects people most. In large parts of the developing world, irrigation remains the backbone of rural economies. However, smallholder farmers make up the majority of the world's rural poor, and they often occupy marginal land and depend mainly on rainfall for production. They are highly sensitive to many changes - droughts, floods, but also shift in market prices. However, rainwater is rarely integrated into water management strategies, which usually focus exclusively on surface water and groundwater. Countries need to integrate rainwater fully into their strategies to cope with water scarcity.

One aspects of the management strategy for water scarcity is to seek for other unconventional resources that might reduce the stress over the normal water resources. These unconventional resources could lead to a reduction in water resources that being lost in secondary water uses activities. In this study one of those resources is being explored and its different possible usage activities being discussed.

Air Conditioning Mechanism

Due to the increased air temperature as a result of the greenhouse effect, the demand for air conditioning has considerably augmented. Air conditioners have many types such as window, split and mobile systems. In general such types compose of three main parts; a compressor, a condenser and an evaporator where the first two of which are usually located outdoor.

The working fluid arrives at the compressor as a cool, low-pressure gas. The compressor squeezes the fluid. This packs the molecule of the fluid closer together. The closer the molecules are together, the higher its energy and its temperature. The working fluid leaves the compressor as a hot, high pressure gas and flows into the condenser. The air conditioner outdoor part has metal fins all around. The fins act just like a radiator in a car and help the heat go away, or dissipate, more quickly. When the working fluid leaves the condenser, its temperature is much cooler and it has changed from a gas to a liquid under high pressure. The liquid goes into the evaporator through a very tiny, narrow hole. On the other side, the liquid's pressure drops. When it does it begins to evaporate into a gas.

As the liquid changes (transferred) to gas and evaporates, it extracts heat from the air around it. The heat in the air is needed to separate the molecules of the fluid from a liquid to a gas.

The evaporator also has metal fins to help in exchange the thermal energy with the surrounding air.

By the time the working fluid leaves the evaporator, it is a cool, low pressure gas. It then returns to the compressor to begin its trip all over again.

Connected to the evaporator is a fan that circulates the air inside the house to blow across the evaporator fins. Hot air is lighter than cold air, so the hot air in the room rises to the top of a room.

There is a vent there where air is sucked into the air conditioner and goes down ducts. The hot air is used to cool the gas in the evaporator. As the heat is removed from the air, the air is cooled. It is then blown into the house through other ducts.

This continues over and over until the room reaches the desired cooling temperature. The thermostat senses that the temperature has reached the right setting and turns off the air conditioner. As the room warms up, the thermostat turns the air conditioner back on until the room reaches the temperature.

It was explained how the house temperature can be dropped but have not addressed the humidity. Part of the function of air conditioning is to dehumidify the house air. Let's look at humidity reduction. For instance, when cold lemonade has been poured into a glass on a hot summer day, the outside of the glass may sweat. That's because the air around the glass has been cooled down to a point where it cannot hold all of the moisture that's in it as vapor, and the humidity falls out as condensation. The evaporator coil works the same way. If one think of the evaporator coil as an on Evaporator Coil cold glass of lemonade, it is easy to imagine how the outside of that coil will sweat as the warm, moist air from the house passes over it. The liquid in the coil is very cold. As the air outside the coil gives off heat, it also loses its ability to hold moisture. Condensation forms on the outside of the evaporator coil. The air gives up its moisture as it passes over the coil. It is to be noted that the drier air helps people feel cooler by allowing sweat to evaporate from their skin. The moisture that forms on the coil is collected in a pan below the coil. The water is drained from the pan through a condensate tube to a floor drain or sink, to the outside or some other acceptable discharge point. This describes the way how the water is produced during the air conditioning operation.

METHODOLOGY

Field Measurement was carried out to collect water sampling from new and old air conditioners operating at Hydraulics Research Institute, National Water Research Centre. During sampling, the amount of the distilled water was estimated using a standard collection bottle with stop watch. Purified bottles were utilized for the sake of chemical and biological analysis of the concerned samples. The analysis was performed at the Central Laboratories for Water Quality and Environment of the Ministry of Water Resources and Irrigation. Six samples were collected and analyzed. Three of the samples were biological analyzed to determine the total bacterial count for 22°C and 35°C. The results of the chemical and biological analysis are depicted in the following section.

RESULTS AND DISCUSSION

The water samples were analyzed and the results were compared to World Health Organization (WHO), guidelines for drinking water quality, Third Edition, Volume 1, recommendations, Geneva 2004 and the Egyptian standards as per the Health ministerial decree number 108 and 301 of 1995.

Bacteriological Quality

Three samples were analyzed to derive the total bacteria count and compared to WHO and Egyptian Standards.

Table 1: Comparison of bacteriological parameters of the water samples and the WHO and Egyptian Standards

Parameter	1	2	3	WHO Standards	Egyptian Standards
Total Bacterial count (22^{o}C)	3	5	2400	**Must not be detectable in any sample**	
Total Bacterial count (35^{o}C)	12	8	4000		
Total Coliform	0	0	0		
Fecal Coliform	0	0	0		

It is to be noted that samples 1 and 2 were collected from new air conditioners compared to the third sample that obtained from an old air conditioner with no maintenance. The total bacterial of the new air conditioners is less compared to the old one. According to WHO and Egyptian standards, no allowance is to be made to any type of bacteria within the water samples. However, it can be revealed from Table 1 that heating can produce in significant reduction of the number of bacteria.

The source of bacterial is caused with the bio-films that form within the air handling system. The contamination of air conditioners is particularly acute in warm climate areas that require lengthy air conditioner operation without the opportunity to permit the moisture producing coils and drip pans to dry. Most of the drip pans are not designed to drain completely and thus harbour microbial growth in air-conditioning units.

As noted by Khurana (2003) that the condensation producing apparatus of air-cooling equipment is recommended to be regularly cleaned and disinfected. However, such routine maintenance is often overlooked, and the use of conventional disinfecting techniques creates problems because of the dissipation of disinfectants into the air flowing through the system exposes many occupants of buildings and vehicles to allergies and illnesses difficult to trace and diagnose. Microbial contamination of indoor air is a major cause of illness among individuals within office buildings and the like having sealed windows wherein air circulation is only through central cooling and heating units.

Based on the above, it is thought that the air contamination within the air conditioning system infected the collected water that inspected during the present water sampling analysis. It is also evidence that the length operation of the air conditioners produces large amount with bacteria.

Chemical of Health Significance

Table 2: Comparison of chemical parameters with the WHO and Egyptian Standards

Parameter	1	2	3	4	5	6	WHO Standards	Egyptian Standards
Magnesium (Mg)– mg/l	3.54	1.10	1.40	1.50	1.20	1.10	**--**	**150**
Nitrite (NO_2)– mg/l	0.20	0.20	0.20	0.20	0.20	0.20	**3.00**	**0.02**
Nitrate (NO_3) – mg/l	0.20	0.20	0.20	0.70	0.78	1.15	**50**	**44**
Arsenic (As) – mg/l	0.01	0.01	0.01	0.01	0.01	0.01	**0.01**	**0.05**
Barium (Ba) – mg/l	0.037	0.045	0.050	0.051	0.046	0.052	**0.70**	**--**
Cadmium (Cd) –mg/l	0.008	0.003	0.0005	0.0005	0.0005	0.0005	**0.003**	**0.005**
Copper (Cu) – mg/l	0.002	0.010	0.008	0.044	0.041	0.018	**2.00**	**1.00**
Nickel (Ni) – mg/l	0.005	0.005	0.005	0.005	0.005	0.005	**0.02**	**--**
Lead (Pb) – mg/l	0.005	0.005	0.005	0.005	0.005	0.005	**0.01**	**0.05**

The above table shows the chemical parameters that of significant effect on the human being health. From one hand, the mineral contents are so small compared to the required quantities as per the Egyptian and WHO standards. This is anticipated as this type of water is distilled where the mineral contents are filtered out. On the other hand, the heavy solid such as Lead is very small and below the tolerated quantity.

Substances of Aesthetic Significance

Table 3 shows the parameters represents the substances of aesthetic significance. The pH of the distilled water is within the tolerated range as per the Egyptian Standards. However the parameters that are necessary for human health such as Calcium, Sodium Sulfates, etc are considerably trivial.

Based on the comparison of the water sampling parameters and the WHO and Egyptian standards, it is not recommended to use such water for drinking. This type of water could be utilized for watering of landscape.

Table 3: Comparison of Substances of aesthetic significance parameters with the WHO and Egyptian Standards

Parameter	1	2	3	4	5	6	WHO Standards	Egyptian Standards
pH	7.35	7.70	7.32	7.19	7.31	7.44	--	6.5 ~ 9.20
Total Dissolved Solids (TDS) – mg/l	42	33	36	32	29	27	--	1200
Calcium (Ca) – mg/l	5.60	4.80	4.80	4.20	3.90	3.80	--	200
Sodium (Na) – mg/l	1.00	3.40	3.70	3.20	2.80	3.00	--	200
Chloride (Cl) – mg/l	1.45	4.00	4.70	4.30	4.00	4.00	--	500
Sulfate (SO_4) – mg/l	2.88	7.00	7.10	5.40	5.00	4.70	--	400
Aluminum(Al) – mg/l	0.065	0.01	0.015	0.018	0.01	0.01	--	0.20
Zinc (Zn) – mg/l	0.036	0.005	0.005	0.005	0.005	0.005	--	5.0

Collection System and Discussion

The simple collection system that can be designed is illustrated in Figure 1. This figure shows the collection system of eight air conditioners installed on a four stories building. The collective underground tank is to be constructed in the vicinity of the building.

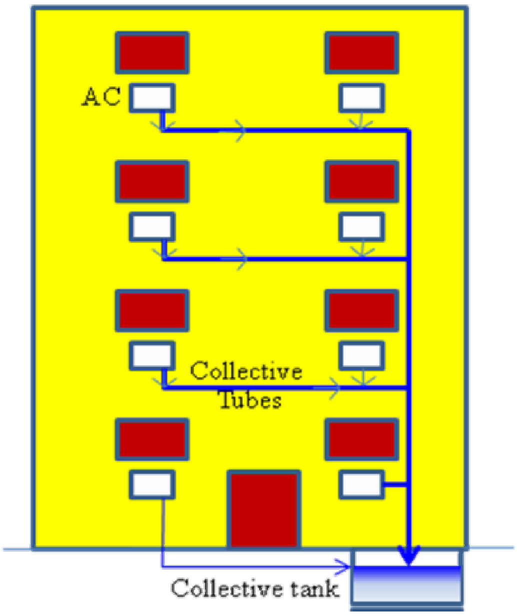

Figure 1: proposed water collection system of water released of air conditioners

The water stored in the tank may be connected to a main network system or might be pumped to be employed in the same building, if needed, for flushing toilets. The other employment could be watering the landscape.

Although the amount of water produced and collected through the proposed system might not goes above 2% compared to the total consumption of a community living in an eight apartments building however in some of the very hot areas like the gulf areas where number of air-conditions is extremely high (could reach 4 air-conditions per apartment) and the working period is very long the amount of produced and collected water could be very considerable amount. This water if being collected and used in several secondary water usages activities like toilets flushing, car washing, landscape watering,…etc., might lead to the reduce the pressure on the resources for safe and clean water.

For example, if a standard toilet cistern pushes 9-11 liters of water down the toilet pan with every flush. Over the period of a year, that adds up to around 50,000 liters for the average household. So for an eight apartments building, this sums up to 400,000 liters per year. On the other hand, for the same building the eight air conditions are assumed to operate for 8 hours in which one hour produces 2 liters of distilled water. The produced water from air conditioners processes is (8 air conditioners x 2 liters x 16 hours x (8 months x 30 days) = 61,440 liter/year) means that for an eight months of the year 25% of the water used for the flushing can be saved.

On the other hand, this unconventional water resource could be considered as renewable water while it could be produced and collected whenever there is a need for air-conditioning.

CONCLUSION AND RECOMMENDATION

An unconventional resource of "distilled" water production through the processed indoor air conditioning humidity was introduced. Comparison of water sampling quality against each of the Egyptian and "WHO" standards revealed that using the produced "distilled" water for drinking is objectionable. However, such water can be employed in many other activities such as watering of landscapes, flushing toilets or even washing cars. It is believed that the latter activities shall considerably reduce the consumption of the fresh waters. It can be concluded from this study that the amount of collected water through this unconventional resource can save a considerable amount of fresh water that could be employed in secondary water usages activities.

It is recommended that more studies should be carried out to investigate the exact amount of water that could be collected through this resource especially in the hot countries like the Gulf area countries and feasibility study of the collection system would be proposed.

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