
8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

Onsite food waste processing as an opportunity to conserve water in a medical facility case study, Abu Dhabi

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Abstract

This paper presents the case for soil and water conservation combined with waste recycling strategies in a desert type climate healthcare environment, which is based on the need for Abu Dhabi to decrease desalinated potable water consumption and increase its waste recycling rate to reduce environmental impact. The work documented in this paper forms part of the first author’s Professional Doctorate change project in the United Arab Emirates (UAE), at a medical facility in use since 2015. The project is investigating two aspects: the feasibility of reusing both the site produced organic biological waste as an organic fertilizer and the effluent produced for landscape irrigation. For this paper the sole aspect of the effluent will be discussed. The context is a newly built medical facility in Abu Dhabi with a 21,600m² building footprint area surrounded by a 29,000m² vegetated open spaces. The city, located on the south west coast of the UAE, is dominated by sandy and salty soil, high temperature and humidity [1]. Five types of effluent generated by three types of dehydrators have been tested for general characteristics, inorganic and organic compounds, and metal parameters and analysed against local authorities’ parameters limits to verify compliance and establish suitability for landscape irrigation and water feature reuse. The effluent test results show absence of microbiological contaminants. The quality of the effluent shows that secondary and tertiary water treatment would be needed to regulate the BOD, turbidity and pH levels to align with the local regulation water recycling requirements. The next steps are for the facility dehydrator effluent to be tested onsite to provide an account of its quality for reuse and for selecting a tertiary treatment type if necessary suitable for landscape irrigation. This to understand how food waste processed onsite can impact the environment, operation and maintenance cost and practices, greenhouse gas emissions, and building systems energy consumption. This study may be relevant to local competent authorities responsible for making and adjusting standards on non-clinical wastewater reuse and recycling should dehydrators be reused at a larger city scale.

Keywords: Sustainable medical buildings; non-clinical wastewater reuse; food waste; LEED; Middle-East

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1. Introduction

This paper discusses an intervention methodology as part of a Professional Doctorate change project in Ecological Building Practices, being undertaken by the first author at a Medical facility in Abu Dhabi. The Medical facility was rated as a Gold United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) New Construction and Major Renovation (NC) standard in 2014.

This action research project focuses on the water food waste nexus for water conservation strategies (Fig. 1(a) below in a desert type climate healthcare environment, which is based on the need for Abu Dhabi to reduce desalinated potable water consumption and chemical fertilizer use in order to reduce environmental impact and operations cost.

The Middle East North Africa (MENA) region including the United Arab Emirates (UAE) has the lowest fresh water resource endowment in the world [3]. Currently the MENA region suffers a water deficit (demand is greater than supply) and with increasing population and per capita water use demand is projected to increase further by 60% in 2045 [4]. The medical facility landscape is as large as its building footprint representing more than 50% of the site. The water irrigation demand has been estimated at 375m³/day, at peak demand in the July summer month. The hospital includes an existing condensate water treatment system, which treats condensate water (estimated at 161,500m³/year) from the air cooling system of a quality suitable for use as irrigation water and water features make up. The short fall in condensate water availability during the winter months (five months/year or 19,728m³) is proposed to be met by using additional alternative water sources and by soil engineering improvement. The latter strategy is currently being tested onsite. And to date (July 2016) the results are promising, showing a potential 50% to 60% water saving for landscape irrigation, which would decrease the deficit to 2.5 months or 4,132m³/year [5].

In addition, and as part of the USGBC LEED Existing Building Operation and Maintenance (EBOM) certification, the medical facility is working on innovation in operation, namely onsite food waste to organic dehydrated biological waste. The purpose of USGBC Innovations in Operations is to recognize projects for innovative and exemplary building features or practices that generate environmental benefits. The medical facility food waste management strategy is based on the Food Recovery Hierarchy (Fig. 1b above) developed by U.S EPA [2]. Essentially, the medical facility is focusing on source reduction and composting as the two main strategies for meeting the Reduce, Reuse, Recycle, known as the 3Rs goal. Recycling food waste means conserving embedded energy in materials, avoiding greenhouse gases emissions, particularly methane, from landfill and incineration and preserving the environment from pollution [6]. Beyond the food waste reduction strategy [7] one of the proposed solutions to achieve recycling is the use of a dehydrator onsite to process food waste into fertilizer. In addition to reusing this onsite produced organic fertilizer, the opportunity to reuse the effluent generated (estimated at 146m³/year) by the equipment was sought. In comparison to the generation of condensate water this effluent quantity is minimal. But should this onsite solution be adopted by others, this small quantity could quickly become an ocean of wasted water at a city scale. The expected outcome of this action research is to investigate if wastewater generated by a dehydrator can meet regulatory recycling water and quality requirements for reuse, so that the need to draw high energy intensive with their associated carbon emissions for desalinated potable water from the municipality, can be minimized. This is to encourage the authority to amend their water standard, so that hospitals can collect and reuse non-clinical non-potable water for their irrigation, water features and potentially toilet flushing to avoid wastage, but also to reduce the need to use desalinated water treatment, which also has a very high cost (0.5-1 USD/m³) in comparison to conventional sources (0.05 USD/m³) [8].
2. Outdoor water conservation in Abu Dhabi

2.1. Background

Abu Dhabi, the capital city of the United Arab Emirates (UAE), comprises of Dubai, over two-thirds (67%) of the country’s total populations [9], which is mainly urban. Abu Dhabi is the largest of the seven Emirates occupying more than 80% of the country’s total land mass [10]. Today the UAE population is 8.2 million, which represents a 75% growth since 2009 [9]. As a response to the region’s rapid urban growth, in cities such as Abu Dhabi, Doha, and Dubai, building construction has expanded. These buildings, used for both residential and commercial purposes, feature inoperable windows; combined with the region’s rising temperatures, ‘high rises create a huge energy demand to power air-conditioning systems’ [3]. Middle East countries rank last in renewable freshwater availability per capita compared to other regions of the world. Currently, 13 Arab countries are among the world’s 19 most water-scarce countries [11]. Per capita, water availability in eight Middle East countries is below 200 m³ per year. Currently the UAE has only a two-day desalinated water storage capacity, making the country vulnerable to any disruption in its desalination plants [3]. Abu Dhabi has embarked on a massive US$5 billion program, based on the aquifer storage and recovery approach, to use local aquifers as strategic reserves for desalinated water [12].

The peak demand forecast for water is said to more than double by 2030 [13]. The Abu Dhabi Emirate annual water consumption is estimated to be 2.49 billion m³, which is expected to reach 5.86 billion m³ by 2020 [14]. It is worth noting that the water desalination process theoretically requires approximately 0.86kWh/m³ of desalinated water and the actual desalination process requires approximately 5kWh/m³ of desalinated water [15]. Hence there is a strong correlation between water and energy, desalination being high energy intensive and though participating in the negative effect of greenhouse gases, “Abu Dhabi’s demand for electricity fluctuates with seasonal cooling load, but does not mirror seasonal water demand. This means that for certain times of the year, electricity is a waste by-product of the emirate’s thirst for desalinated water. Water conservation is a gateway action for reducing energy use and ultimately carbon footprint” [16]. Per Abu Dhabi’s inventory, the greenhouse gases (GHG) with the highest rate of emission was carbon dioxide (CO₂) which accounts for 79% of all emissions. The energy sector (e.g. electricity and water desalination, oil and gas, transport, manufacturing) accounted for 73% of direct GHG emissions [17].

2.2. Local and International Regulations

Because air conditioning condensate water reuse is not considered wastewater by local authorities [18, 19], medical facilities are authorized for reusing air handling unit (AHU) air conditioning condensate water for both landscape irrigation and outdoor water features subject for the system to be maintained to local and international standards and codes [20, 21, 22]. The mandate for the reuse of alternative source of water for landscape irrigation is not unique, air conditioning condensate water reuse is already strongly encouraged in Dubai (UAE) [23], in San Antonio, Texas (U.S.A) [24] and by U.S standard [25]. In 2015, Dubai released the Green Building Regulations and Specifications [23], which stipulates that air conditioning condensate water for all new buildings with a cooling load equal to or greater than 350 kilowatt (kW) must be recovered and used for irrigation, toilet flushing, or other onsite purpose where it will not come into contact with the human body [23]. Condensate collection is also required by ANSI/ASHRAE/USGBC/IES Standard 189.1 [25] and the International Green Construction Code for air conditioning units that are above a certain cooling capacity set in more humid climates [26]. The city of San Antonio in Texas U.S.A mandated the reuse of air conditioning condensate water for all new construction [24]. Whilst, air conditioning condensate water reuse forms part of the Department of Municipal Affairs and Transport (DMAT) Building Code 2013 [20] and the Abu Dhabi Urban Planning Council (UPC) Design Public Realm [27], the Pearl Building Rating System [28], makes it an elective not a requirement. In addition, DMAT [20] encourages the reuse of fire sprinkler test water from the main test drain, a strategy not reflected within the Estidama program. Moreover, the health authority released an update standard early 2012 on the use of wastewater in the Emirate of Abu Dhabi, which stipulates that “any release of treated or untreated wastewater from Nominated Healthcare Facilities to land, sea, surface water, ground or air is strictly prohibited in order to protect the natural environment” [19].

Hence, one of the Principles and Objectives of Abu Dhabi Vision 2030 was to create plans that respond to the desert climate, respecting water assets and making use of sustainable energy and waste techniques and technologies where appropriate [29]. Based on the Abu Dhabi 2030 vision policy agenda prescribing the reduction of water demand and encouraging efficient distribution and alternative sources, the Environment Agency Abu Dhabi (EAD) developed
The Water Resources Strategy for the Emirate of Abu Dhabi 2014-2018, to encourage the management and conservation of desalinated, groundwater and recycled water [30]. The launch of this new water production strategy is evidence of the importance Abu Dhabi is taking about water conservation and as such reusing wastewater has become a priority in the UAE [31].

2.3. Green Building Rating Systems

Measurement tools demonstrate how sustainable practices such as those implemented on a facility and its estate contribute towards a reduction in the ecological footprint. Some countries like the UAE have made these tools a part of their infrastructure promoting legislation, standards, and policies [32]. One of these standards is the Pearl rating system, which has a dual mandated and voluntary approach. This is determinant when planning environmental strategies to reach mandatory levels: 1 Pearl for residential developments, and 2 Pearl for Government buildings [33]. Water and energy combined accounts for more than 50% of the credits points in the system within the three typologies of buildings, communities and villas. Any of the ‘Precious Water’ credits for landscape irrigation clearly mandates the use of non-potable water [28].

In the UAE, LEED has already been well established having been adopted by Dubai World and private organizations. Sigmon and Johnson [34] highlight that the “water conservation and hydrology benefits of today ‘green building standards is not being harnessed to its full potential’. Whilst, the new LEED version four has made water conservation a much more stringent strategy to achieve, Outdoor Water Conservation is still a credit not a prerequisite with a target of 30% to be achieved for any new construction LEED registered buildings [35]. Overall, most LEED projects achieve some water efficiency credits, but not all water credits are generally met. Sigmon and Johnson [34] conclude that more research is needed to establish which levers would be most effective to minimize and maximize water use across different regions for maximal benefit and which strategy at government level would lead to restorative contributions to hydrological resource.

2.4. Healthcare Context for Water Efficiency

Fresh water is a finite resource of which healthcare organizations are major consumers [36]. Fig.2. (a) below shows that 75% of potable water is used for medical equipment and mechanical systems, which means that for their intended use this water may not need to be potable, but of an acceptable quality [18]. For example, non-conventional sources of water are less costly to treat than they are to desalinate [5]. The Water Sense U.S EPA partnership program [37] published specific information on medical facility water use, which is summarized in Fig. 2 (a) below. In a typical U.S medical facility, total water use can be broken down into five major categories: sanitary, HVAC, medical processes, cafeteria/food service, and laundry. The largest uses of water in medical facility are cooling equipment, plumbing fixtures, landscaping, and medical process rinses [38]. A water use study published in 2002 showed a range of water use from 68,750 to 298,013 gallons per year per bed for medical facility in the size range of 133 to 510 beds [39].

While the water consumption among the urban and rural medical facility was dependent upon factors like services provided, inpatient/outpatient visits, equipment used, age of facility, and other factors, this large range indicates that some medical facility are using water more efficiently than others [37]. The U.S EPA [38, 40] recommends to reuse rainwater/storm water, foundation drainage, Reverse Osmosis filter and membrane reject water, cooling equipment blowdown water and A/C condensate (namely treated alternative sources of water) for medical facility landscape irrigation, toilet/urinal flushing, make up water for decorative water features, fume hoods scrubbers, and processes.

3. Case Study

The medical facility irrigation system is mostly subsurface to limit the evaporation of water during cycles, thus reducing the quantum of irrigation. The irrigation system comprises of 120 zones with automatic valve control directing the flow of water to the irrigation zones. The irrigated areas, mainly occurring at night, include native and draught resistant grass areas, green roof planting, succulents, ground covers, shrubs, palms, trees, and a future planned crop area [41]. Large outdoor water features are located on the ground floor surrounding the facility, which are designed to be fed predominantly by treated condensate water.
3.1. Existing System Description

Referring to Fig. 2. (b) below raw condensate water from the HVAC system is collected in two raw condensate storage tanks (#1 and #2) located in the basement of the facility. These tanks are constructed in concrete. The purpose of the condensate water treatment system is to treat the condensate water from the AHU equipment collected in tanks #1 and #2. The condensate water treatment system has been designed to achieve a pH value of the treated condensate water between 7.5 and 8.0 by circulating the acidic raw condensate water through limestone contactors [42]. These tanks supply water to both the water features and the landscape irrigation. An ozone/Bromine combined treatment system is installed to treat the condensate water used for the water features to a level required by local authorities [18, 20, 21].

![Fig. 2. (a) Healthcare facility water use [39]; (b) Air conditioning condensate water treatment system configuration.](image)

3.2. Air Conditioning Condensate Water Recovery

Among other sustainability strategies for achieving LEED EBOM gold level, the medical facility is targeting 100% non-potable water use for its landscape irrigation. Figure 3 below, shows there would be enough water to meet the estimated annual flush fixture water demand (11,800m$^3$) for the facility. However, the current Abu Dhabi standards don’t refer to the reuse of condensate water for toilet flushing in medical facilities [19, 20]. It is also unclear from the legislator if this condensate water could be stored for future use for a prolonged period of time (e.g. to cover for the winter deficit), or if on-site wash condensate water recycling is permitted for medical facilities, i.e. water feature water recirculation. This is currently being investigated, as part of the Professional Doctorate change project. This said, all tanks are quite small (200m$^3$) and storing water in summer to fill for the winter deficit (4,132m$^3$) would involve a prohibitive budgetary infrastructure alteration. However, that could be a viable option to study for other projects subject to EAD and Health Authority Abu Dhabi (HAAD) authorities’ approval and for it to be investigated at very early design stage.

As shown in Fig. 3 below, by reusing the onsite air conditioning condensate water all year around, the project is aiming at saving 160,000m$^3$ (equivalent to 68 Olympic swimming pools) of desalinated potable water and subsequently reducing CO$_2$ emissions. This water savings is based on the capacity of the existing air conditioning condensate water to produce 442m$^3$ of water in average per day to satisfy an irrigation demand from 190m$^3$ in winter to 385m$^3$ per day in summer and 82m$^3$ per day for water features [42]. For approximately 17% of the year (approximately 45 days each year) the irrigation demand will not be met by the treated condensate generated at the site. The total estimated volume of water anticipated to be made up is approximately 19,728 m$^3$ predominantly occurring from December to April of each year. However, similarly, the theoretical model (Fig. 3) does not make allowance for precipitation, which occurs in the winter period each year. As such the shortfall is an approximation that cannot be accurately determined in a theoretical model. This model will be verified by measuring water use and water produced by sub metering on the raw condensate water tanks line [42]. Since condensate is formed from
moisture in the air, it is relatively high-quality water. Therefore, it can be collected and used on-site within relatively little treatment [43, 44] subject to the implementation of a strict maintenance program [20, 21, 22].

3.3. The Water Food Waste Nexus

The shortfall in condensate water availability during the winter months is proposed to be met by alternative water sources for reuse, which currently are being investigated, e.g. Sterilizer Reverse Osmosis membrane reject water, fire sprinkler test water and dehydrators wastewater. As shown at Fig. 4 (a) below it is estimated that 450m³ of water is used for testing fire sprinkler every year. And should the dehydrator be in use all year round, an additional 146m³ of effluent per year could be lost to drain or be gained for reuse. Here is how. The medical facility has estimated food waste production for the next two years (2015-17) to establish impact on the environment and cost of hauling. It is estimated that at full operation, 800 Kgs of food waste per day may be generated, which would represent more than 300 tons of food waste a year. Yet as shown at Fig. 4 (b), food waste is made up of 80% water. Considering the environment and financial impact the anticipated waste generation can have, the medical facility has sourced some alternative options to provide an account of food wastewater recycling feasibility. The proposed dehydrator could reduce food waste from 80 to 90% its weight, which represents 12 m³ of wastewater per month (Fig. 4 (a)).

4. Methodology

4.1. A Mixed Method Approach

To analyze and evaluate the potential for reusing the effluent generated by the dehydrator, the medical facility is used as both an action research intervention and the main case study (Fig. 5). The mixed method approach, is presumed
to have considerable benefits since any method has distinctive strengths and weaknesses [45, 46]. Combining quantitative and qualitative methods for the pluralistic epistemological reasons is not only viable it would significantly improve management research in terms of mainstream positivist criteria [45]. The action research is used to inductively test the water conservation strategy onsite. This intervention undertaken at the medical facility will become the case study, which will be used to deductively reflect on this experimental approach. The research is investigating the collection and reuse of alternative water sources for landscape and water feature use. To test a hypothesis or a theory, Kumar [46] notes that researchers will need to go through a process that comprises three phases: (1) constructing the hypothesis, (2) gathering appropriate evidence, (3) analyzing evidence to draw conclusions as to the validity of the hypothesis. It is though essential that data collection methods are valid and free from any bias to be meaningful.

Fig. 5 Water balance diagram.

The medical facility case study implies undertaking a comparison of an on-site system as opposed to the use of municipal desalinated potable water in terms of environmental impact, energy consumption, operation maintenance, greenhouse gases emissions, and cost savings. Part of this analysis is the development of a water balance, which comprises five elements as illustrated at Fig. 5, A to E. The data will be able to be collected and analysed via sub flow meters, Flow meter 1 to 4 as illustrated in Fig. 5. The data may be captured via the Building Management System (BMS) daily. Additionally, this water data will be compared with water bills to cross check collected data accuracy and establish cost savings. The action research focuses on elements B and C, whereas the case study on A and E (Fig. 5). This action research benefit is to help provide an account on the effect of non-potable water on landscape for water efficiency and water deficit offset feasibility analysis.

4.2. Water Sampling
Water sampling has been done on various dehydrator effluents around Abu Dhabi, and the air conditioning condensate water at the medical facility has also been tested to compare the quality of the dehydrator wastewater and the AHU condensate water. The intent was to measure both the raw air conditioning condensate water and the air conditioning condensate water after treatment. These results are then compared with the raw dehydrator effluent. Air conditioning condensate water being considered processed water by the regulator it is not subject to restrictions for irrigation and water feature use. However, to meet local requirements [18, 21] the medical facility air conditioning
condensate water is treated by secondary and tertiary treatment as shown at Fig. 2(b) above. Liquids from the dehydrator are extracted from food waste by evaporation and subsequent condensation within the unit and so liquids are not pure water. In the current state of legislation, the health authority [19] prohibits the recycling of wastewater in healthcare environment. That means the dehydrator effluent is not considered an acceptable candidate for water reuse. Whilst, an opportunity was sought to investigate this wastewater reuse, which would account for 46,000 liters per year or 12m³/month water savings.

5. Results

This section presents results of non-potable water tested carried out by an independent certified Emirates Authority for Standardization and Methodology (ESMA) laboratory. The effluent rejected by the dehydrator is evaluated against the maximum allowable concentration or characteristic of Restricted Substances as specified in Schedule B of the Regulation and Supervision Bureau (RSB) for the water, wastewater and electricity sector in the Emirate of Abu Dhabi, Trade Effluent Control Regulations 2010 [47]. However, to give an account of its potential for reuse, the maximum allowable concentration or characteristic of Restricted Substances is evaluated against Schedule A1 and A2 of the RSB for the Recycled Water and Biosolids Regulations 2010 [18]. The effluent test results are outlined at Table 1, below.

Table 1: Results of water quality analysis for different locations in the UAE.

<table>
<thead>
<tr>
<th>Water types/location</th>
<th>BOD (mg/l)</th>
<th>pH</th>
<th>Turbidity (NTU)</th>
<th>TSS (mg/l)</th>
<th>Enterococci (CFU/100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw air conditioning condensate water/ medical facility</td>
<td>8</td>
<td>7.60</td>
<td>&lt;3</td>
<td>&lt;6</td>
<td>absent</td>
</tr>
<tr>
<td>Treated air conditioning condensate water/medical facility</td>
<td>4</td>
<td>7.76</td>
<td>&lt;3</td>
<td>&lt;6</td>
<td>absent</td>
</tr>
<tr>
<td>Dehydrator type 1 effluent/ university</td>
<td>65</td>
<td>3.15</td>
<td>4</td>
<td>&lt;6</td>
<td>absent</td>
</tr>
<tr>
<td>Dehydrator type 2 effluent/ hotel A</td>
<td>18</td>
<td>3.54</td>
<td>Not tested</td>
<td>10</td>
<td>Not tested</td>
</tr>
<tr>
<td>Dehydrator type 2 effluent/ hotel B</td>
<td>5</td>
<td>3.02</td>
<td>7</td>
<td>8</td>
<td>absent</td>
</tr>
<tr>
<td>Desalinated domestic water/ medical facility</td>
<td>&lt;3</td>
<td>7.70</td>
<td>&lt;3</td>
<td>&lt;6</td>
<td>absent</td>
</tr>
<tr>
<td>RSB recommended value for water recycling [18]</td>
<td>10</td>
<td>6-10</td>
<td>5</td>
<td>10</td>
<td>40</td>
</tr>
</tbody>
</table>

Water quality tests were performed on five samples drawn from four different sources in Abu Dhabi to compare dehydrators effluent quality to air conditioning condensate water and desalinated domestic water. Table 1 presents the most critical values of these tests with the RSB recommended values [18] for each included as a reference. Whilst, not all parameters are shown, substances measured were sanitary, salinity, irrigation criteria for trace elements, heavy metals, and microbiology.

6. Discussion

Wu et al [48] have stated that wastewater reuse has now been universally recognized in arid and semi-arid regions of the world. Before wastewater can be reused as a water source for landscape irrigation, recommended pre-treatment should be addressed to minimize risks to human health, environment soil quality and crop productivity and quality [48]. In the medical facility case scenario, it is observed that Biochemical Oxygen Demand (BOD) and pH are the main substances that need attention for aligning with the RSB recommended values. BOD, COD and DO reflect the biological treatment efficiency whereas Boron SAR and Chloride are set for crop protection [48]. The test results for the latter parameters meet the RSB limits. While secondary treated wastewater can be reused for irrigation, tertiary treatment is recommended for unrestricted irrigation use [48]. Currently the facility uses an ozone/chlorination treatment system, which deem suitable to treat the dehydrator wastewater for water feature demand. At the same time, in the current configuration of the system (Fig. 2. (b)) above, it may be best using a more environmental friendly and cost effective UV irradiation treatment system should the dehydrator effluent be reused for landscape irrigation.
7. Conclusions

The paper gives an account of the potential for processed water and non-clinical wastewater reuse in healthcare settings, in Abu Dhabi. Evidence is presented for wastewater reuse opportunities for landscape irrigation from food waste effluent generated equipment. In addition to the Abu Dhabi building code, recommended air conditioning condensate and fire sprinkler test water reuse, additional alternative water sources are widely available in healthcare buildings to provide for water recycling for outdoor reuse. In this case scenario, detailed non-potable water quality tests have been conducted to suggest for implementation of a treated wastewater strategy that could reduce substantial environmental impact and increase cost savings. The nature of the wastewater quality is determined by the food waste quality input. And this study has shown that microbiology substances results have met the authority water quality requirements. By adjusting pH, BOD and turbidity levels by tertiary treatment the water seems to be a good candidate for landscape irrigation water reuse.

A review of the Abu Dhabi Emirate strategies relevant to the study have set out the significance of the wider field of water consumption directions in the industry. Local policies and standards related to outdoor water strategies are presented, which identified gaps. A lack of directions from the regulator has been identified in terms of air conditioning condensate water reuse and water treatment. This brief review shows that the regulator has a large role to play in setting out directions for water conservations to protect the environment, the public and the future of the UAE. In addition, the climatic context in which the medical facility sits clearly identifies opportunities for treating onsite non-clinical wastewater safely and processed water collection and reuse.

The proposed methodology is the use of the medical facility as both a case study and an action research intervention. The latter will be designed to test the facility onsite effluent generated by the dehydrator on a medium term to establish if it is a good candidate for reuse in a desert type climate. This intervention will be measuring the impact of using onsite alternative water sources in a healthcare setting to alleviate the use of desalinated potable water in terms of electrical consumption, capital cost investment and greenhouse gas emissions. The results may be relevant to local authorities responsible for making and adjusting standards on non-clinical wastewater reuse and recycling should the dehydrator effluent be reused at a larger city scale.

Acknowledgements

The authors would like to thank the academic and medical facility team for their support.

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