

## **Evaluation and Alternatives for Water Resources Development in Abu Dhabi Emirate**

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### **Abstract**

Abu Dhabi emirate depends on conventional and non-conventional water resources to meet ever increasing water demands. Conventional water resources are limited and surface water is almost absent due to the scarcity of rainfall coupled with arid conditions. Groundwater is mostly brackish and non-renewable. Over-pumping practices have resulted in a severe decline in groundwater levels and quality. A large portion of the freshwater demands in the emirate is covered by desalinated water. The future development in Abu Dhabi area depends mainly on the availability and sustainability of the water resources. The overall objective of the proposed alternative water policies for Abu Dhabi is to secure long-term water supplies while meeting strict criteria for public health requirements and for socio-economic and environmental sustainability. Prospects and possible alternatives include (1) artificial recharge of groundwater using excess desalinated water, (2) artificial recharge of wastewater, (3) cloud seeding and (4) Surface storage. The development of additional water resources in the emirate will require well planned, detailed and integrated studies of the potential for surface, groundwater and non-conventional water resources, and cooperation between agencies in these studies. Only then can the most appropriate feasible options be selected from among the many recognized techniques, including, surface storage, groundwater recharge, wastewater reuse and weather modification. According to the evaluation result, the selected options and alternatives for water resources development in Abu Dhabi emirate could be the recharging of aquifers by the excess water from desalination plants. Although cloud seeding alternatives seems to be beneficial, but based on the expertise it needs more research studies to recommend it.

**Keyword:** conventional, non-conventional, artificial recharge and cloud seeding

### **Introduction**

In the last few decades, the United Arab Emirates has witnessed a remarkable development in the various aspects of life. The standard of living in the different emirates has been developed. Agriculture, industry and commerce activities were developed. Such fast development imposes a tremendous pressure on natural resources including water. UAE depends on conventional and non-conventional water resources to meet ever – increasing water demands. As the world population is expected to grow from the current 6.1 billion in 2005 to 9.3 billion by the year 2050 (UNESCO,2000), water demand is expected to soar. At the same time, water resources will steadily decline because of growing demand at an unsustainable rate, rising pollution levels and expected climate change. Population growth rates are currently about 4% /yr and the projected 2010 population for Abu Dhabi Emirate

is about 2¼ million (EAD).

The UAE is an arid country with no permanently existing natural surface water, limited ground water resources and water demand exceeding the availability of water from renewable resources. Freshwater from desalination plants is used to bridge this gap. Critical freshwater uses include agriculture, landscaping and household activities which are all expected to increase as the population expands. The annual groundwater recharge in UAE is about 130 Mm<sup>3</sup>. Groundwater abstractions during 2002 exceeded the annual replenishment of about 1987.5 Mm<sup>3</sup> which is about 75% (M.A.Dawoud,2005).

#### **General outline about Abu Dhabi Emirate**

Abu Dhabi is situated along the Arabian Gulf, between latitudes 22.5 °, 25 ° North, and longitudes 51 °, 55 ° East. It has an area of 67,340 km<sup>2</sup>, equivalent to 86.7 % of the country's total area. The city of Abu Dhabi is the capital of the United Arab Emirates. Climate in Abu Dhabi is arid with very high summer temperatures. The coastal area, where the bulk of the population lives, has a hot and humid climate in the summer (May-October) with maximum temperatures of almost 50°C and relative humidity often reaching 100%. Most of the rainfall occurs during the winter (October-March) with February being the wettest month. Spring and summer witness only occasional concentrated heavy rainfalls. The rainfall distribution is highly variable over space and time. In 2003, the mean rainfall per month was about 2.9 mm (January), 0.2 mm (February), 3.9 mm (March) and 44.7 mm (April), respectively, while there was no precipitation in the remaining months (GTZ,2002).

The surface geology of Abu Dhabi is concealed under a cover of sands, which form dune ridges reaching heights of about 150 m inland. The coastal plains are dominated by evaporitic flats, sabkhas, which extend more than 80 Km southwards into the sand deserts (NDC,1995). Several thousand metres of consolidated marine and continental sedimentary rocks underline the Emirate of Abu Dhabi. The rocks are relatively flat-lying and aerially extensive beneath most of the Emirate. Near the Oman Mountains, sedimentary rocks are folded, faulted, and up-lifted in a complex pattern. Unconsolidated alluvial deposits cover the sedimentary rocks near the mountain front. Much of the sedimentary rocks and alluvial deposits are covered by unconsolidated sand dunes.

#### **Water resources in Abu Dhabi**

Abu Dhabi Island is a sabkha coastal area, where the ground water is very saline. Low recharge rate of groundwater is observed with less than 4% of total annual water used and no reliable perennial surface water resources (EAD). Therefore the required drinking water is obtained by desalination of seawater exclusively. Al – Ain city, which is situated on the mainland, close to the border with the Sultanate of Oman, is supplied with fresh water from wells and desalinated water. Percentage of each resource in the emirate is shown in Figure 1.

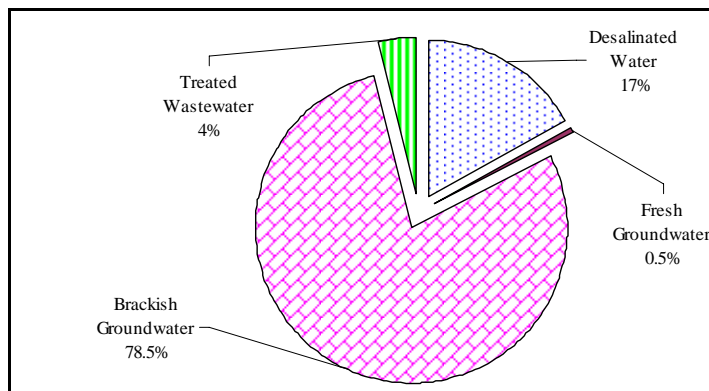


Figure 1 Abu Dhabi Water Resources, 2003 (EAD)

In the Western and Central region, south of the Abu Dhabi –Al Ain highway, villages and settlements on the mainland and on islands were historically supplied by inland well fields. However with decreasing supplies from these fields these well fields, desalination has been introduced on the coast .In the area toward the Dubai border, villages and settlement on islands, coastal zone and inland are supplied either with water from wells or from desalination plants. The conventional water resources of Abu Dhabi are estimated at annually, of which about 38 % is contributed by brackish water, 20 % comes from saline groundwater reserves and only 13 % is the portion that is fresh water with TDS < 1500 ppm. 23 % are provided from desalination plants, which are distributed all over the emirate. It is worth to mention that the only 6 %, which comes from treating wastewater, is totally consumed by the agricultural sectors (EAD). At present 16.5 km<sup>3</sup> (16.5 bio m<sup>3</sup>) natural fresh groundwater exists in Abu Dhabi Emirate (GTZ,2002).

### Groundwater

Approximately 50,000 wells exist in the Emirate of Abu Dhabi. Most of them are located at the agricultural hotspots of the Emirate (Al-Ain, Al Khazna-As Saad, Siwehan-Al Hiyar, Al Wijan and the Greater Liwa area). The estimated total average abstraction rate from these wells in 1994 was 81 MIGD of freshwater and 187 MGD of brackish water (GTZ,2002) Using groundwater as source for desalination process was limited in Al-Ain region. Several reverse osmosis plants were operated in Al- Ain city like Um Al Zumol, Al Qooa and Al Wegin. Table 1 shows the quantity of water received from different sources to Al-Ain region. Recently, the dependence on the groundwater in water production has been decreased and all the plants have been banned due to the depletion of saline water source except Um Al Zumol plant, where as the daily production of this plant is 36,000 gallon per day, the desalinated water is imported from Abu Dhabi and Al-Fujairah Emirates to Al-Ain. (ADDC).

Table 1 Quantity of water coming from different sources to Al-Ain region (2005) (ADDC)

Source of Water	Quantity (MGD)
Taweelah Desalination Plant	35.5
Umm Al Nar Desalination Plant	17
Fujairah Desalination	81.63
Northern Region Well fields	5.39
Southern Region Well fields	0.2

Most of the groundwater in the Emirate is found in unconsolidated dune sand aquifers, alluvial deposits, shallow sedimentary formations, and shallow fractured/karstified limestone formation. Fractured limestone and uncemented alluvial gravel deposits are the most prolific sources of groundwater in the Eastern Region of the Emirate, while most of the groundwater resource in the Western Region is found in dune sand aquifers. About 1,440 Km<sup>2</sup> in Al Ain area and 2,400 Km in the Greater Liwa area are underlain by fresh groundwater. Fresh groundwater mostly occurs in the shallow part of the aquifers, while the salinity of the deeper-seated groundwater increases significantly with depth, ranging from slightly brackish to highly saline water. The imbalance between natural recharge and groundwater pumpage has resulted in groundwater level declines locally of more than 100 m since 1990 west of Al Ain (GTZ 2002, W.M.Alley et al 2002) . Abu Dhabi has been aggressive in planting forests and the amount of forest area has grown steadily with the years. Ground water contains varying concentrations of chemical constituents that have dissolved from host rock or have been introduced through man's activities.

#### **Desalinated water**

The conventional water resources in Abu Dhabi do not meet the national demand for water, so the non conventional resources are intensively used nowadays, especially desalinated water. The remarkable economic and demographic development of the United Arab Emirates (UAE) is closely associated with desalination technology; where 98% of the water supply comes from desalination of seawater or brackish water (C.Sommariva, 2001). Figure 2 shows the distribution of desalination capacity in the UAE by emirates in which 61% of the total capacity is in Abu Dhabi emirate. Last statistics (ADWEC,2001) revealed that water produced from the desalination plant increases annually, and the dependence on the groundwater source decreases due to the depletion of this source.

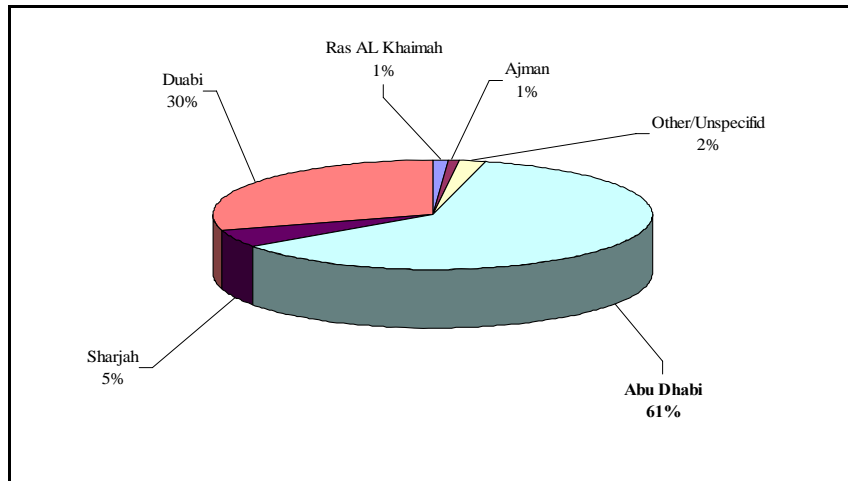


Figure 2 Distribution of desalination capacity in the United Arab Emirates, by emirate (K.Wangnick, 2000 )

This confirms that desalination is the central source of water in UAE now and in future, especially when the demand and consumption per capita increase sharply. The desalinated water resources in Abu Dhabi composed of Multi Stage Flash (MSF), Multi Effect Distillers (MED) and Reverse Osmosis (RO) plants. Some of the RO plants are utilized to desalinate some of the saline groundwater as in Al-Ain. In order to meet both the qualitative and quantitative requirements for drinking water standards, the majority of desalinated water is produced from MSF plants due to their integrity with power generation and their ability to handle large capacity of water. It produces high quality product water (between 2 and 150 mg/l of total dissolved solids). The majority of desalinated water is produced from Arabia and Taweelah complexes plants, while the remaining is produced from desalination plants in Mirfa, Shuweihat and small plants in Sila, Dalma Island, Jabal Dhanaha and Sir Baniyas Island (H.Al-Hossani et al) Table 2 shows the water production from each company in 2004 with the share percentage of these companies. In order to meet the domestic and agricultural water demands, which are functions of population and urbanization growth, Abu Dhabi are going a head with desalination plants construction, despite their relatively enormous costs.

Table 2 Water production from ADWEA's company, 2004 (ADWEC).

Company	Water Production (MG)	Water Production (%)
Al Mirfa Power Company	7772	6
Al Taweelah Power Company	25586	18
Arabia Power Company	51126	38
Bainounah Power Company	4610	3
Emirates CMS Power Company	17190	12
Gulf Total Tractable Power Company	23664	17
Shuweihat	1082	1
UWEC	7293	5
Total	138,323	100

### Treated wastewater

Abu Dhabi now is considering treated wastewater as new non-conventional source of water and it is proved without saying that they are one of the most advanced in using this technology of recycling sewage water and applying it in the proper ways to supplement portion of needed water to agriculture and landscaping purpose. Not only that, but environmentally safe and proved to be very effective. This huge concern towards this type of resource came as a consequence of immense efforts done by concerned authorities in the emirate regarding reserving water resources and protecting environment. Great benefits (advantages) could be obtained from using this source of water. The recycled/municipal wastewater is under the authority of Abu Dhabi and Al-Ain. It is produced and used for greenery (not farm) in the whole emirate. The total quantity of recycled water produced from Abu Dhabi and Al-Ain Municipalities is about 54.6 MGD .

The economic feasibility of the treatment of sewage water and its re-usage depends on many factors, such as the cost of treatment and the degree of required treatment in comparison to the cost of producing alternative water resources for the same purpose. As a matter of strategic management of using this source, treated wastewater was one of the solutions to decrease the stress on the natural water resources. Advantages of using treated wastewater are:

Protecting the environment from pollution. Wastewater will be produced irrespective of whether or not it is used, since treatment is essential from the environmental point of view.

Provide a dependable non-conventional water resource in Abu Dhabi so we can reserve the existing freshwater resources from depletion. As agricultural water demand and environmental needs grow, recycled water will play a greater role in the overall water supply.

Reusing treated water is better option than disposal from the economic and environmental point of view. Most of the recycled water in Abu Dhabi is used however when there is overload, fractional portions of unused treated wastewater are discharged into the sea.

Since the main purpose of recycling water is the irrigation, it doesn't need to be very high quality of water. The cost of providing additional good quality water of the same volume as that of the wastewater produced still generally is higher than the wastewater. The cost of producing one m<sup>3</sup> of desalinated water is 3.08 UAE Dirham (US\$ 0.84) (A.M.Helal et al,2004); whereas the cost of producing one m<sup>3</sup> of treated sewage water is 0.4 UAE Dirham (US\$ 0.58) (Abu Dhabi municipality)

Generally, agriculture soil in UAE can be considered as slight to high salinity (EC= 4 -12 dS/m), high calcium carbonate content (>30%) and the sandy textures. 54.5 % of the soil in Abu Dhabi were considered as moderately (EC 4-8 dS/m) and strongly (EC 8 – 16 dS/m) saline. (A.A.Soad et al,2003)

Most of soils in Abu Dhabi are of a sandy texture have only traces of organic matter, and deficient in major nutrients. Treated wastewater reuse can provide low TDS water and nutrients to soil and plants, especially nitrogen and phosphorus, and thus may reduce the total requirement of commercial fertilizers (W.K.Al-zubari,1998) Saltwater intrusion in coastal areas can be prevented by recharge of groundwater with treated wastewater. Most of the aquifers are experiencing quality deterioration due to seawater intrusion or over-extraction. (W.K.Al-zubari,1998)The imbalance between natural recharge and groundwater plumage has resulted in water-level declines of nearly 50 m since 1990 in Al-Ain (NDC,1995).

Although of the above mention benefits, question still remains about the possible use of treated sewage water in agricultural irrigation, and chemical and biological effects on the plants, soils and groundwater, in addition to the possible health hazards associated with the use of treated-sewage water in irrigation. It is possible to avoid such consequences by safe treatment, which ensures the elimination of pollutants, and purification of the water to be used for crop irrigation. It is essential to educate the community appropriately to avoid any adverse effects on the environment. Public awareness and knowledge regarding various aspects of wastewater are generally limited, which result in a generally negative public attitude toward the various uses of reclaimed water. This could be overcome by educating the community and design programs by professors to encourage confidence (W.K.Al-zubari,1998). Total Treated Wastewater Production in Abu Dhabi is about 130.85 Mm<sup>3</sup>/yr, with a 109.568 Mm<sup>3</sup>/y production from the Central & Western Region and 21.28 Mm<sup>3</sup>/y for the Eastern. Example of waste treatment plant in Abu Dhabi is Mafraq Waste Water Treatment Plant (MWWTP) which has been created to receive and treat the sewage from Abu Dhabi city and surroundings. The facility located 40 km from Abu Dhabi in the Mafraq area, and 40 m above sea level. It is designed to handle a daily flow of 290,000 m<sup>3</sup>d (76.6 MGD) (Abu Dhabi municipality).

It employs tertiary treatment which produces water with high quality. The treated water is reused for irrigation, landscaping and agricultural activities and to protect the environment from pollution. The plant receives both industrial and the municipality's waste. The sewage undergoes complex biological treatments to free the water from

bacteria. As well as providing an extremely high quality effluent to be used for irrigation around the city of Abu Dhabi, the final effluent has been used to provide a green oasis around the plant which is now home to a wealth of wildlife (EAD) successful example of the using treated water in Abu Dhabi is Al Wathba Wetlands Reserve, which attracts thousands of migrant waders and other waterfowl during the winter, and has also been the site for the first recorded breeding anywhere on the mainland of the Arabian Peninsula of the Greater Flamingo in the last 70 years. The lake's success is the use of recycled water from the Mafraq Sewage Treatment Plant, which treats wastewater from Abu Dhabi city. A substantial quality of this is used to irrigate fodder fields at the nearby Al Wathba Camel (EAD).

#### **Evaluation of current policy alternative**

Fresh water is of critical important to economic activities in the emirate, where water is provided by desalination plants and ground water reserves that supply water for mostly agriculture use. During the past 10-15 years, the underground water supplies have gradually decreased. In addition, seawater intrusion has led to increase in salt levels of previously uncontaminated ground water in some locations. For nearly tow decades, the water resource community of Abu Dhabi had a growing concern about the sustainability of its fresh water resources, since ground water levels and well fields in many locations have declined over the period. These facts lead to a growing concern about the sustainability of current aquifer withdrawals given the rapid growth occurring throughout the Abu Dhabi. The evaluation will be mainly about desalination since it is major source of water in the emirate which may had impacts on the human health , social and environmental effects.

#### **Thermal Desalination**

Since Thermal desalination contributes around 96% of the desalination technology in Abu Dhabi (GWI, 2004) the focus will be about its advantages and disadvantage.

#### **Adverse Impacts of Desalination**

A seawater desalination plant affects the coastal water quality. This is due to many reasons starting from the construction phase which results in changes in land use of the site area. The heavy equipment will compact the beach sands which in turn, will lead to disturbance of the microbial species available on the beach. Excavation and dredging will produce sediments that will cause turbidity. Increase of suspended solids and turbidity, mostly concentrated around the installation of intake and drainage pipes (T.Hoepner,1999) and it will cause respiration problems for the fish and other animals. Discharges from desalination plants have the following characteristics: (1) relatively high temperature which is usually 10°C to 15°C above ambient seawater temperature leading to a reduction in the amount of dissolved oxygen (DO) in the seawater , (2) highly saline brine which contain residual chemicals from the pre- treatment process, 3) heavy metals from corrosion or intermittently used cleaning agents, (4)scaling suppressants, and metal ions stripped from the pipeline (copper, nickel, lead, etc) ( R. Einav et al,2002).



The huge saltwater circuit and the large surfaces are liable to biological growth, which is regulated by antifouling additives. Chlorine which is added to the desalination plant feedwater to prevent biofouling on heat exchanger surfaces is a strong oxidant and highly effective biocide. Residual levels in the discharge may therefore be toxic to marine life in the discharge site (A.Areiqat et al,2005).Acoustic contamination on seawater reverse osmosis desalination plants is important. High pressure pumps and energy recovery systems, such as turbines or similar, produce significant level of noise over 90 dB(A).Therefore, they should be located far away from populated areas and equipped with appropriate acoustic technology to reduce noise level (J.Jaime et al,2005).

Noise is another problem and is, in fact, a controlling factor in setting the background noise levels of our environment. The World Bank guidelines stipulate that noise levels in industrial/ commercial areas should remain below 70 dB and that background levels should not be increased by more than 3 dB (I.S.Al-Mutaz,1994).The unwanted by-product of seawater desalination processes is brine, highly concentrated salt water (up to factors of 2.5)( A.Purnama et al,2005). Additionally to the destructive saline properties of the concentrate, in the case of thermal desalination, the produced brine is usually hotter than the local recipient water body; this has also been shown to cause further environmental damage, especially to fragile ecosystems such as corals. (G.L.Meerganz,2005). Un-ionized ammonia: Ammonia is one of the substances of concern as unionized ammonia (NH<sub>3</sub>) is very toxic to aquatic species.

### **Positive Impacts of Desalination**

Adequate and safe water supply is one of the key elements for healthy communities. The production of water through desalination creates a water source with a reliable supply. Reliability of water supply is very important for public health and sanitation, since it guarantees the required amounts of water for humanitarian basic needs. Because of the absence of natural water resources in the emirate, the positive impacts of desalinated water on public health are greater than any other region also, the quality of water produced by desalination is meeting most of international standard of potable water. Furthermore, the construction and operation of desalination plants could create new business activities for local and international contractors, consultants and suppliers. There is a prosperous desalination market, with large business opportunities. The desalination business is also creating employment opportunities for people with various technical and professional backgrounds .Producing water by desalination allowed alleviating the pressure on traditional water resources, especially, the ground water, which is subjected to over-abstraction.

### **Prospects and possible alternatives**

The future development in Abu Dhabi area depends mainly on the availability and sustainability of the water resources. The overall objective of the proposed alternative water policies for Abu Dhabi is to secure long-term water supplies while meeting strict criteria for public health requirements and for socio-economic and environmental sustainability. Prospects and possible alternatives include (1) artificial recharge of groundwater using excess desalinated water, (2) artificial recharge of wastewater, (3) cloud seeding and (4) Surface storage.

### **Artificial recharge of groundwater using excess desalinated water**

Artificial recharge is one of the many techniques used to manage water resources and should be regarded as one method to be used in conjunction with a wide range of others, including surface storage and demand management. Groundwater recharge is preferred because there are negligible evaporation losses, the water is not vulnerable to secondary contamination by animals or humans, and there are no algae blooms resulting in decreasing surface quality (P.Fox,1999).

Aquifer storage recovery (ASR) is a technology for storing large water volumes underground through wells during times when it is available and recovering this water from the same wells when needed to meet peak emergency, long-term storage or other needs. Artificial recharge could also be done through spreading water on the surface to increasing the water table gradient from a source of recharge (R.David 1998, A.Mukhopadhyay et al 1998). Artificial groundwater recharge is already carried out in many countries all over the world .Modern artificial recharge applications reach back for about 50 years while a few applications were back to more than 100 years. Most artificial ground water recharge is still limited to surface application such as basins or river channels (W.M.Alley et al,2002), recently an increasing amount of recharge is carried out through wells.

In the Gulf region, Kuwait, Oman and Qatar are planning to make use of artificial recharge applications (I.Gale, R. Einav et al 2002). Dams in mountain areas of the eastern part of the Peninsula, collecting water from seasonal rainfalls to cause additional infiltration and storage for agriculture purposes, can be considered as an early utilization of artificial recharge in the area (P.Fox,1999).

In Kuwait, artificial recharge of the Kuwait Group aquifer was first tried by Parsons in 1964, using a recharge pit in the Rawdhatain depression for the purpose of collecting surface run-off during occasional rainstorms. Recharge experiments through injection wells were undertaken by the Ministry of Electricity and Water at the Rawdhatain water field during 1972-1973 and in 1977 to study the clogging effects of injection and quality changes during the recovery phase (M.N.Viswanathan et al,1998).

Abu Dhabi Emirate is investigating the possibility of storing large quantities of desalinated seawater in the underground by artificially recharging existing fresh groundwater resources. Two pilot projects of artificial recharge being structured, one in Al-Ain region and the other one in the Western region. In Abu Dhabi, two studies have been undertaken, The first pilot project was undertaken by National Drilling Company (NDC) in Al-Ain in 1998 where excess water from Umm Al-Nar and Taweelah plants is stored in the underground in the surficial aquifer system for future recovery during time of needed. The aim of the study was to assess the feasibility of augmentation and revitalizing the critical groundwater resources of Al-Ain area. The results of the study indicates that the aquifer storage recovery is a viable alternative for augmenting the depleted aquifer (Hutchinson) .The second pilot project is located west of the highway from Madinat Zayed to Meziyrah and comprises an area of about 10 Km in EW direction and about 1.5 Km in NS direction. It is designed for an infiltration capacity of 500 m<sup>3</sup>/h and recovery capacity of 750 m<sup>3</sup>/h. Shallow to medium deep aquifer north of the Liwa Crescent was selected as study area for the following reasons: (1) existence of a large natural fresh groundwater lens north of the Liwa-Crescent (salinity less than 1,500 ppm, partly meeting the TDS-limit of the international World Health Organization drinking water standard (1,000 ppm) ,(2) sufficient lateral extension and aquifer thickness, (3) sufficient depth of groundwater table, (4) relatively homogenous lithology,(5)remoteness to already existing well fields,(6)

favourable hydrochemical conditions. It has pointed out that the feasibility study has clearly shown that the recharge and efficient recovery of desalinated water into an existing freshwater aquifer is feasible on a large scale (GTZ,2002). The purpose and advantages of it to the Emirate are as follows:

Replenishment of depleted aquifer systems To meet the variation in the seasonal demand. By storing water underground and recovering it later using Aquifer Storage Recovery (ASR) techniques, it is

possible to access water when it is most needed, during the drier months or as per demand.

Creation of a drinking water supply back-up system in case of emergency.

Creation of strategic reserves. Surface engineering constructions of similar size are impossible to build.

The quality of the native groundwater can be improved by recharging with high quality injected water (M.N.Viswanathan et al 1998, T.Hoepner,1999).

In aquifer systems, the artificially created reserve is safe in terms of hygiene.

Depending on the applied technology, evaporation or seepage losses can be eliminated(R.David et al,1995)

Artificial recharge can significantly increase the sustainable yield of an aquifer and is environmentally attractive, particularly in arid regions.

Most aquifer recharge systems are easy to operate.

ASR-surface structures require minimal land compared to other techniques (an acre or two per well).

#### **Artificial recharge of wastewater**

Groundwater recharge with reclaimed wastewater is an approach to water reuse that results in the planned augmentation of groundwater for various beneficial uses. It can be used to lessen the long term supply vs. demand imbalance faced by the Emirate.

Wastewater as a source is of predictable volume with a fairly uniform rate of flow over time and of constant, but inferior quality. Wastewater requires significant treatment before being considered to be acceptable quality for aquifer recharge and to minimize the extent of any degradation for groundwater quality. Variation in summer and winter demands can leads to have more than half of the water to be surplus in winter season (N.Rashid,2005). Some countries dump this excess wastewater into sea while it could be beneficially stored underground for later use.

The water levels in brackish groundwater fields are declining due to the over pumping of groundwater to meet landscaping and gardening requirements and by recharging we could help replenishment of such aquifer. Advantages of such techniques could be in increasing the cycle time of recycling and thereby allows more time for biodegradation of contaminations that degrade more slowly (P.Dillon et al,2006). The major problem of such recharge is the cost of treatment to a level, that it could be used

for unrestricted use without any major health hazardous. Normally, treatment to drinking water standard is required if recharging groundwater has potential of being reused as potable supply (M.N.Viswanathan et al,1998). Reclaimed wastewater can also be used for irrigation purpose. The other problem is psychological barrier that prevents people from using wastewater. Economic of water reuse might be considered the most important factor in determining the potential of water reuse. Such economic could be influenced by several factors such as: (1) level of treatment, (2) geographical locations of users and (3) size of treatment plants (M.F.Hamoda,2004).

Public acceptances, as well as the associated cost for pipelines, pumping stations, etc. to convey the water from the wastewater treatment plant to where it is needed are also constraints added on the utilization of reclaimed wastewater. Use of the reclaimed wastewater for irrigation of fodder crops is more easily accepted than irrigating crops for direct human consumption and use for potable supply.

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## تقييم بدائل تطوير مصادر المياه في أبوظبي - الإمارات

### انتصار الكشيري

هيئة مياه وكهرباء أبوظبي - الإمارات العربية المتحدة

تعتمد إمارة أبوظبي على المصادر التقليدية و غير التقليدية للمياه لمواجهة الزيادة المستمرة في الطلب على المياه. المصادر التقليدية للمياه محدودة و كذلك المياه السطحية تكاد تكون معدومة نظراً للنقص في الأمطار بالإضافة إلى الطقس الحار. المياه الجوفية غالباً مالحة وغير متجددة كما و أن الاستخدام الجائر لها أدى إلى تناقصها بشكل حاد في الكم و النوع . المياه الخلاء بواسطة محطات التحلية تغطي الجزء الأكبر من الطلب المتزايد للمياه في الإمارة. و تجب الإشارة هنا إلى أن التقدم و التطور للإمارة يعتمد على توفر مصدر مستمر للمياه والحفاظ عليه, من هذه النقطة جاءت فكره البحث في تقييم مبدئي للمصادر المائية الحالية في أبوظبي لضمان مصادر المياه من الناحية الصحية و الاجتماعية و الاقتصادية و البيئية واقتراح البدائل التي تشمل : (1) التغذية الاصطناعية للمياه الجوفية باستخدام الفائض من محطات التحلية. (2) إعادة استخدام مياه الصرف الصحي. (3) التخزين السطحي للمياه وأخيراً. (4) تغذية السحب. إن تطوير مصادر جديدة للمياه يحتاج إلى خطة و برنامج منظم يشمل دراسات وأبحاث مكثفة للمياه السطحية والجوفية والغير التقليدية. هذا بالإضافة إلى التعاون المشترك بين الجهات المسؤولة لتحقيق الهدف المطلوب, بعد ذلك يمكننا تحديد البديل الأنسب من التقنيات المتوافرة. خلصت هذه الدراسة إلى أن التغذية الاصطناعية للمياه الجوفية قد تكون أفضل الوسائل المتاحة لإدارة المياه في الإمارة كما وأنه لا يجب أن نستبعد تغذية السحب إذ أنه مجدي ولكن بحاجة إلى المزيد من الدراسات.