Wastewater reuse gains momentum in Mediterranean and Middle Eastern regions

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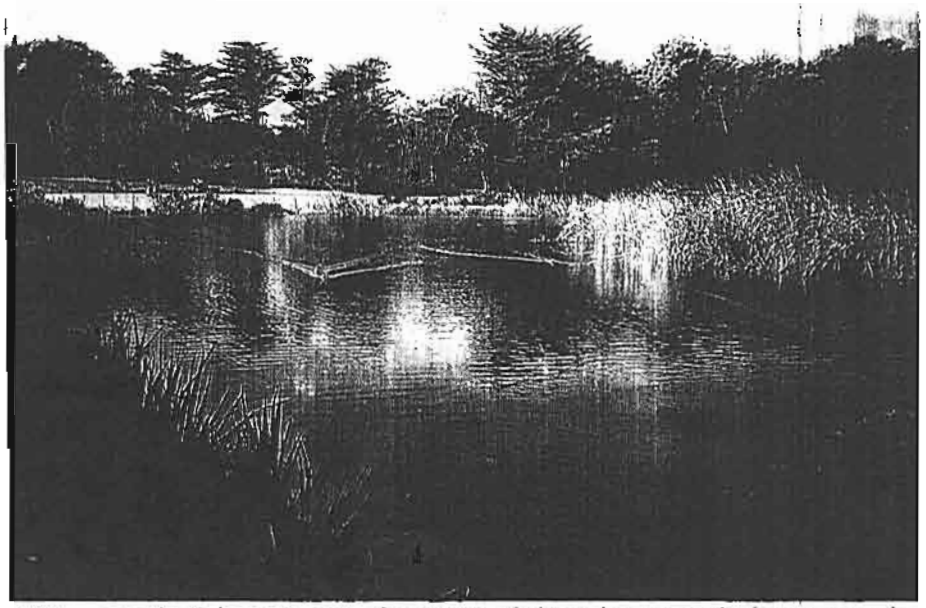
Water reuse is one of the numerous non-conventional water resource management activities promoted during the last decade within the framework of the International Drinking Water Supply and Sanitation Decade (IDWSSD) to meet an ever increasing water supply demand. Even though the concept of wastewater reuse is not a new technological breakthrough for mankind, global interest is quite new, and its popularity in semi-arid and arid countries is on the rise. As a result, reclaimed domestic wastewater, especially for irrigation, is now considered an economic and environmentally sound method of water resource management in these countries.

In general wastewater reuse can be classified into two broad categories, namely: indirect and direct reuse. Indirect reuse has been practiced for centuries, even for millennia, in some countries. Wastewater is discharged in this unplanned method with or without treatment into fresh surface water courses or into underground aquifers, and withdrawn downstream in its diluted form. Unfortunately, health and environmental effects are not given adequate attention and outbreaks of health hazards frequently occur as a result.

The end use of the wastewater is always distinctly defined in direct reuse, serving for beneficial purposes. In contrast to indirect reuse, health and environmental effects are given high priority so wastewater is applied only to controlled and monitored environments.

Accelerated urbanization and industrialization among Mediterranean and Middle Eastern nations have brought upon extreme pressure on the region's existing water resources. Ambitious agricultural development activities, geared to feed increasing populations, tend to siphon off more and more water; thus, water demand often exceeds available water resources. This situation alone has brought about special interest in the reuse of wastewater as a water resource.



900A macrophyte lagoon, one of a series of three lagoons which serve as the tertiary treatment stage of the wastewater reuse project on the island of Porquerolles, France. *Photo Creidt: CEFIGRE*

Many nations have also begun to pay more attention to environmental protection by establishing stringent effluent standards. Substantial investments on new waste treatment technologies have been made by polluters to meet the environmental requirements on effluent. In many of the oil-rich Middle Eastern nations, high quality effluent is now commonly available in constant volumes throughout the year. In turn, the increased availability of high quality effluent reuse has boosted the use of effluent reuse throughout the Middle East.

Reclaimed water can be used in a wide spectrum of activities such as agriculture, industry, groundwater recharge, and potable water supply. Each of these methods are associated with different health and environmental risks. In most of the semi-arid and arid countries, wastewater reuse activities are predominantly concentrated in the agricultural sector.

Since the beginning of the 1980s, many countries have been using untreated or partially treated domestic wastewater for agricultural activities. Today, these nations are very well aware of the possible health risks and the environmental degradations associated with uncontrolled water reuse practices. It is interesting to note that these countries, in realizing the financial gains possible in wastewater reuse projects, have implemented an increasing number of controlled projects as an alternative to exploring new water resources. Although wastewater reuse is widely practiced in these regions, no nation has mastered this technique yet.

Regional wastewater reuse activities

Morocco

Most of Morocco's territory is considered arid or semi-arid. Geographically situated between the Atlantic Ocean and the Saharan desert, Morocco receives very little and irregular rainfall. Despite the nation's growing interest in developing the mining and tourist industries, agriculture remains the

major economic activity, and it keeps growing. This progression invariably augments the demand for irrigation water; however, like many North African countries, Morocco's natural water resources are confined mainly to groundwater.

Presently, wastewater reuse operations are geared only towards agricultural activities. Treated effluent is used in simple gravity surface irrigation systems in agricultural sites located primarily in the outskirts of urban areas, equipped with wastewater treatment systems.

Currently, only 60MCM of treated wastewater is used to irrigate 6,000ha, out of the 350MCM of treated wastewater available. By the year 2000, it is expected that the treated wastewater used for irrigation will rise to 500MCM, which could be applied to some 50,000ha of cultivated land.

Tunisia

Reclaimed domestic wastewater is considered as a potential water resource that can help bridge the gap between demand and supply of water for irrigation needs in Tunisia. Water resource development for agricultural projects has been given top priority by the government of Tunisia, due to its arid and semi-arid climate. Agriculture also plays a vital role in the nation's economy: 31% of the population is involved in this sector.

For the past two decades, the government has financed many hydrological projects, including dams, deep wells, shallow wells, diversion canals, which permit the mobilization of 60% of the nation's water resource potential.

Tunisia is classified into three climatic zones, namely; the northern Mediterranean region, which represents 23% of the country, has a humid and semi-arid climate with an annual rainfall between 400-1000mm; the arid central region, 31% of the country, has an annual rainfall of 300mm; and the southern region, a dry and arid pre-Saharan area that encompasses 46% of the country, has an annual rainfall of less than 200mm.

The first agricultural application of wastewater in Tunisia as a water resource dates back to early 1960. Twenty-six sewage treatment plants now exist, treating approximately 100MCM/year, and 10% of it is used for irrigation. The treatment plants employ only primary and secondary treatment. Thirty more treatment plants will be constructed by the end of this decade, and 95% of the treated wastewater is expected to irrigate 20,000 hectares.

Considering the possible health hazards associated with agricultural reuse, Tunisian government authorities are currently preparing standards for wastewater reuse, and guidelines for crop selection and irrigation techniques. The government has adopted a stringent authorization procedure for wastewater irrigation farms to follow in order to eradicate any possible health risk. Each project designed to use treated effluent has to get approval from three different national authorities, namely the Ministry of Agriculture, the Ministry of Health, and the National Environmental Protection Agency.

Kuwait

The use of sewage water for irrigation purposes was practiced for many years in Kuwait, but mostly in an uncontrolled manner. Located in the desert region of the Middle East with no rivers or streams, Kuwait receives only 106mm of annual rainfall. Groundwater is considered to be the only natural water resource, but its exploitation capacity is very limited in comparison to the nation's water demand for industrial, agricultural and domestic activities.

Within the past twenty years, Kuwait witnessed its own rapid modernization from a small fishing community to a very highly technological nation. Desalinated fresh water became the predominant water source. Before the invasion of Kuwait by Iraq in August 1990, desalination capacity was some 164.6 million gallons per day. Even though desalinated water was used for different development activities, its use for the agricultural sector was not considered economical. This constraint compelled the government of Kuwait to consider treated wastewater effluent as a water resource for use in agriculture.

The government of Kuwait made use of modern techniques for treating sewage in order to use the effluent for agricultural purposes. Three major treatment plants, namely: Aridiya, Costal Village and Jahra, were equipped with tertiary treatment systems consisting of chlorination, rapid sand filtration and final chlorination, with the objective to obtain a BOD level less than 1.9mg/l and SS 1.0mg/l.

The government of Kuwait drafted a more systematic high priority plan in the late 1970s and early 1980s to promote wastewater reuse in irrigation. According to this plan, wastewater reuse was employed only in intensive, controlled cultivation in enclosed farm complexes and low water demand plantations in large areas of low population density areas. Nine such effluent reuse sites were eventually developed. The ultimate project objective was to develop 2700ha of intensive agriculture in enclosed farms and 9000ha of forestry.

Bahrain

Wastewater reuse in Bahrain is limited to controlled state farms to prevent any possible health effects. More treated effluent is available than could be used at present, however, because further agricultural development has been stymied by high salt water intrusion into the country's major aquifer.

The state of Bahrain consists of an archipelago of 33 low lying islands, with a total area of 622km2. Until the 1960s, the country's urban and agricultural activities had plentiful access to its major water resource, an underground spring fed from the Damman aquifer in Saudi Arabia. The scarcity of the country's rainfall, which has a mean annual value of 72mm, had no significant influence on the development activities; that is, until the rapidly increasing population, and increasing agricultural and industrial activities took their toll on the water table. Heavy abstraction from the aquifer has lowered the water table. Meanwhile, salt water intrusion into certain sections of the aquifer has prevented any further developments. Currently, the salinity level across the island varies from 2000 -9000mg/l.

The gap in demand and availability of water was progressively bridged with the use of desalinated water, which is mainly used for domestic purposes. The total annual water

consumption is around 168MCM, of which 95MCM is for domestic consumption. The prevailing government policy is to replace two-thirds of the domestic water consumption by desalinated water. The government launched a wastewater reuse scheme in 1984 to further reduce the need for groundwater.

Fifty percent of the population is connected to the country's main sewerage system and treated at the centralized treatment plant at Tubli Water Pollution Control Center. A major portion of this treated effluent is discharged into the sea while the rest (85,000m3/d) undergoes tertiary purification composed of filtration and ozone treatment. This tertiary effluent is used for irrigation. The use of treated sewage effluent is restricted only to controlled state farms to prevent any possible health effects. Nevertheless, because of the difficulties encountered in developing agricultural land, only a portion of this effluent is used.

The government of Bahrain envisaged a three-phase development plan of wastewater reuse schemes, in which 370,000ha will be cultivated using treated effluent by the end of the third phase in 2010. It is noteworthy to observe that the saline content of treated water is expected to decrease as a result of excessive use of desalinated water and improved drainage facilities, which will be beneficial for irrigation purposes.

Jordan

Water reuse is practiced mainly indirectly in Jordan, such as discharging treated effluent into wadis and reusing it downstream for irrigation. Aquifer recharge through wadi beds is quite common, and treated effluent is the only base flow during the dry season.

Jordan's harsh desert climate demands careful development of its existing water resources. Eighty-one percent of the country experiences arid desert conditions with an annual rainfall less than 100mm. Only 9% of the land receives more than 200mm per year. Jordan's total annual available water resources amounts to 1110MCM, of which 880MCM is surface water and the rest is ground water.

Even though 70% of the total water is used for irrigation, water demand for domestic and commercial consumption tends to increase more rapidly than for agricultural needs. Meanwhile, only 60% of the total estimated 47,000ha land is cultivated due to water scarcity. As a result, the water authorities have realized that wastewater reuse will be the best alternative to meet the additional water demand and increase the cultivation land area.

All major cities in Jordan have wastewater collection networks and treatment plants. In 1989, 75% of the urban population (52% of total population) was connected to a sewage system, and this figure is expected to rise to 86% by the year 2005. The total volume of water available from the treatment plant is around 35MCM per year, which is expected to rise to 61MCM/year by 1995.

Water demand often exceeds available water resources.

The national policy on the direct use of wastewater requests that it be practiced at the vicinity of the treatment plants. Such practice is advocated only to the cultivation of silviculture, fruit trees, fodder crops and vegetables which are cooked before consumption. Concurrently, all new treatment plants must incorporate an on-site reuse component. By the year 2000, it is expected that approximately 30,000ha of land will be irrigated using treated wastewater.

Egypt

Wastewater reuse has hardly been realized in Egypt, despite the agricultural constraints caused by the lack of water, but this is expected to change in the next 10 years. A national policy requires all new treatment plants with capacity ranging between 200l/s to 1200l/s to be designed to reuse each drop of its effluent. A project is also planned to irrigate approximately 80,000ha from Greater Cairo's treated sewage. The total capacity of treatment plants may 3BCM by the year 2000, from which 2BCM could be used for agriculture.

Ninety-six percent of Egypt's land is arid desert that accommodates a population of less than 1 million, out of the country's 53 million inhabitants. The northern region near the Mediterranean coast receives an average rainfall of 150mm, but this decreases rapidly until it reaches 25mm only 35km from the seashore. Due to this rainfall pattern, Egypt's water resources have been predominantly based on Nile water for thousands of years.

The Egyptian economy depends mainly on agriculture with the participation of 58% of its population. Considering the rapid boost in population, which will reach 70M by the end of this decade, further expansion of its agricultural sector is inevitable. Ample land exists to cope with this agricultural need, but the main development constraint is water.

Compiled data reveals that there will be a water shortage of 2.4BCM in 1992 and 3.8BCM in 2010. This breach can be bridged by adopting the following alternatives: exploration of groundwater in the Nile valley and its delta; reuse of treated sewage water; and reuse of agricultural drainage water. In the Nile basin, farmers use almost twice as much water needed for irrigation because of poor irrigation methods. Estimates indicate that the availability of irrigation drainage water is to be between 14 to 16BCM/year, of which only 5BCM/year is used for irrigation.

Cyprus

Wastewater reuse for irrigation is considered by the government of Cyprus to be the best solution to the pressing problem of wastewater disposal while preserving the natural environment. Such practice should further boost the tourism industry in this popular island nation.

The Mediterranean island of Cyprus experiences hot dry summers and rainy winters, with an average annual rainfall of 600mm. Even though Cyprus's economy is predominantly based on agriculture, the island's growing popularity among tourists is beginning to play an important role in national development.

Water is a valuable commodity in this island with no perennial rivers or lakes. Similar to other Mediterranean and Middle Eastern nations, rapid urban and rural development

ventures have resulted in the overexploitation of conventional underground water resources. Currently, numerous water resources development projects are being promoted to meet the nation's water demands. Substantial interest has been focused on dam construction since 85% of the precipitation occurs between the month of November and March. Some 350MCM of water storage will be possible when these projects are completed: Cyprus's water demands will be taken care of until the year 2015.

Adequate attention is also being paid to other innovative approaches, and wastewater reuse is one of them. This practice is mainly concentrated on the irrigation sector. According to present wastewater reuse potential, it could be used to cultivate approximately 6% (3350ha) of the total area. The National Agricultural Research Institute in Cyprus is involved in an extensive research project to find out the soil-water-plant relation in wastewater irrigation. The information acquired through these studies will be used to develop national standards and guidelines. Modern irrigation systems, such as drip and mini-sprinkler are highly advocated. With such systems, higher level of salinity and Na content of the irrigation water could be accepted.

France

France enjoys abundant water resources unlike other arid and semi-arid countries in the Mediterranean region. Important man-made canals such as the Canal du Bas-Rhone-Languedoc, Canal de Provence and numerous agricultural water reservoirs provide water to the country's semi-arid regions in its southern Mediterranean coastal area. Wastewater reuse was never even considered as a necessary alternative even in the driest areas of the country since adequate water resources could always be made available.

Numerous wastewater reuse projects exist, however, despite this fortunate situation. During the last decade, frequent drought and increasing numbers of tourists have put excessive demands on ground water resources in many parts of the southern tourist coastal cities. In certain areas, overexploitation of ground water has even led to salt water intrusion problems. In such areas, wastewater reuse was recently considered as a possible alternative to meet seasonal demands. On the island of Porquerolles, wastewater reuse provides a constant water supply used mainly for irrigation, and limits the previously excessive pumping from conventional water resources during periods of drought and high tourist activity.

On the national level, wastewater reuse is practiced in small-scale projects. No national sanitary standards for irrigation exist yet. Possible health and environmental risks are averted in many cases by using appropriate micro-irrigation techniques, similar to practices in other European nations. The Health Ministry authorities, however, are updating the recently published World Health Organization wastewater reuse recommendations

to develop national sanitary guidelines for use in France.

Spain

Wastewater reuse was not considered a viable alternative by the national government of Spain until the late 1980s. Spain's entry into the European Community, however, exposed it to stringent wastewater disposal requirements which call for the construction of more sewage treatment plants. The idea of effluent reuse as an interesting alternative to wastewater disposal, and its potential in the Mediterranean and south Atlantic coastal region to augment existing water supply has become highly promising as a result.

The majority of Spain's 38.5 million inhabitants are concentrated in the coast and in the and in the valley of rivers Ebro and Guadalquivir. Water scarcity only occurs in the coastal region where water forecast studies reveal that water shortages may occur in 2010 in Catalonia, the southwest Mediterranean regions and the Canary islands.

Most sewage treatment plants dispose their effluent into rivers or streams to be used downstream for irrigation. Only a few controlled wastewater reuse projects exist and most are geared for the irrigation sector. Most of these projects have been developed by the private sector or research institutes. Wastewater is also used for irrigating golf courses and public parks in the Canary islands and the Palma of Majorca island.

Wastewater reuse is also being applied illegally in many parts of the country where treated or untreated wastewater is used in agriculture without any legal sanitary control. Lately, the government is planning to establish national standards for wastewater reuse since it is aware of the possible health risks associated with such practices.

Conclusion

Wastewater reuse has always been an integral part of human life. In the past, it was practiced on a small-scale level and all adverse effects were considered as localized phenomenon. It is beyond doubt, however, that effluent reuse will be adopted at a much faster rate and on a larger scale than what was anticipated a decade ago. Therefore, all water reuse practices have to be analyzed in the long-term and in a global context.

Reclaimed water use activities have intensified recently. Unfortunately, these developments are not kept abreast with the creation of adequate sanitary regulations and effective enforcement agencies. This dichotomy has in turn created a spate of environmental and health hazards.

Even though water reuse appears like a simple and appropriate technology, in reality, it is a complex one. It has multidisciplinary interlinkage with different sectors such as environment, health, industry, agriculture, and water resources. In addition, due to these complex interlinkages in many countries, the administrative responsibility of reuse activities is not well defined. Often it falls with the ministries dealing with health, water supply and sanitation,

agriculture, industry, or water resources management, which further complicates the creation of regulations and its promulgation.

Many nations tend to duplicate the stringent standards adopted in western countries. There is an immediate need to overcome this situation and to refine these norms in in accordance with local technical, economical and social factors. In the agricultural sector, attention should be focused on drawing up a national or regional level code of practices emphasizing the relationship between soil, water and plants and irrigation techniques. It is beyond doubt that the nations of this region do not possess adequate manpower resources for effective planning and implementation of wastewater reuse projects. Paramount priority has to be given to personnel training because this sector is the pivotal component of all wastewater reuse projects.

Routine monitoring plays a vital role in any development sector. However, developing countries are paying less attention to this aspect of water resource management. Hence, these nations must focus more on this field, and mainly on health and environmental considerations.

Wastewater reuse is still considered as a subject of academic research that has resulted in the publication of numerous scientific documents and papers. National authorities fail to disseminate this information, circulated mostly within the privileged scientific community, to the real work force. Only a handful of documents that explain the techniques and associated hazards exist using simple laymen language. Due to this situation, farmers are still very dubious of the real value of any water reuse project.

Finally, water reuse projects are planned and implemented based upon only technical and financial feasibility studies too often. Planners tend to discard the beliefs and values of a culture. For example, Hindu and Muslim communities believe wastewater is an untouchable water source, based on their respective religious teachings. In such situations, the communities must be convinced of the importance of water reuse before steps are taken to implement the project, instead of vice versa. A properly planned awareness campaign targeted at political and cultural levels will only increase the chance of project success.

Another stumbling block in the implementation of a reuse project is that politicians regard this technique with suspicion due to cultural reasons and their own vested interests, so they often dare not to venture into this new field. Although wastewater reuse is a scientifically and environmentally proven technology, there is a long way to go before it is genuinely accepted by society.

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