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Successful implementation of closed water cycle approach for industrial wastewater treatment and reuse in Saudi Arabia: a case study

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1. Introduction

During the past three decades, and with increasing water shortages in GCC and most Arab countries, the use of non-conventional water resources such as treated industrial and domestic wastewater has been an integral component of every water strategy in the region. This has been to reduce the gap between increasing demands and limited fresh water supplies, to achieve sustainable water and wastewater services, and to meet sustainable development goals by 2030. In spite of the above facts, the planned targets for the reuse of wastewater effluents remain limited and far below the expectations of the water planners and decision makers in many Arab countries including some GCC countries. This has been mainly due to several factors such as deficiencies in policies, strategies, and technical capabilities, weak governance frameworks including organizational structures, institutional and legal issues, and lack for enough financial and technical supports.

Saudi Arabia has been among few Arab countries that succeeded in adoption and implementation of full-scale industrial wastewater treatment and reuse (closed water cycle) in all industrial cities on national level. This paper describes the adopted policies and executed plans utilizing integrated water resources management tools that enabled Saudi Arabia to achieve such success. It also defines the positive impacts and benefits of such large-scale implementations of wastewater reuse on conservation and sustainability of water and energy.

2. Adopted policies and executed plans utilizing integrated water resources management tools for industrial wastewater treatment and reuse in Saudi Arabia

The remarkable successes of Saudi Arabia in large-scale implementation of treatment and reuse of industrial wastewater in industrial cities have been due to comprehensive adoption and implementation of sound governance frameworks utilizing integrated water resources management tools since the beginning of the new century. These comprised of three main components: creation of enabling environment, development and implementation of sound institutional and legal frameworks, and development and implementation of sound management instruments for successful utilization of public–private partnership (PPP) in implementation of closed water cycle (CWC) approach contracts.

3. Creation of enabling environment

Creation of enabling environment included the following: (i) development of National Water Strategy and action plans in accordance with KSA 2030 Vision which emphasized the reuse of wastewater utilizing PPP schemes, (ii) a royal decree was issued in 2002 approving the recommendation of the Higher Economic Council to adopt PPP schemes in six sectors including the water sector, (iii) strong political support by higher authorities for the adopted strategy, (iv) development of legal frameworks including national water law and enforcement measures that facilitated the execution of the action plans, (iv) identification of investment and financial structures to support action plans.

4. Wastewater reuse market

Development and implementation of wastewater reuse market include (i) development of sound institutional and legal frameworks for sound treatment and reuse of industrial wastewater, that included the establishment of the Saudi Industrial Property Authority (MODON) in 2001 to be responsible for the development of industrial cities including integrated infrastructure and services working in partnership with the private sector, (ii) development of Water Regulator as regulatory body and enforcement agency for protection of interests of all stakeholders, (iii) creation of industrial cities hosting thousands of industrial plants, (iv) development of required infrastructure including water supplies and wastewater collection and treatment facilities, (v) implementation of capacity building and training programs for different levels of technicians, managers and water professionals.

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5. Sound management instruments

Development and implementation of sound management instruments include (i) attraction of private sector to participate in PPP contracts by development of bankable BOT projects and mobilization of additional financing for PPP projects, (ii) selection of proper entity from experienced and qualified private sector that fit for PPP through BOT schemes, (iii) development and execution of transparent and sound PPP contracts, (iv) selection of sound, economic and effective technology to maximize wastewater treatment and reuse such as CWC that leads to zero liquid discharge in industrial plants and cities, (v) development of proper legal frameworks for effective control on qualities of wastewater influents and effluents, (vi) setting of sound KPIs for effective implementation of PPP schemes, (vii) development of fair and regulated water reuse tariff, (viii) development of sound customer services for serving various industrial clients within the industrial cities.

The CWC approach has been introduced and implemented successfully to industrial cities in Saudi Arabia to maximize wastewater reuse, to reduce consumption of conventional water resources, desalinated seawater and electricity, in addition to protection of the environment in accordance with Saudi Arabia's 2030 Vision. In 2008, the first BOT contract for duration of 25 years was agreed and signed with local specialized company for industrial wastewater treatment and reuse in Jeddah Industrial City. This was followed by a second BOT contract for 25 years in 2012 for Dammam and Al-Hassa industrial cities between MODON and specialized private sector company. Similar BOT schemes for other extensions and other industrial cities have been implemented during the past 3 years. In 2012, MODON was overseeing 29 cities, hosting more than 4,700 factories with investments exceeding SR250 billion, and more than 300,000 employees. The number of the industrial cities shall reach 40 by 2019. The produced industrial wastewaters from each factory are monitored to meet special set of quality guidelines prior to be discharged into the wastewater collection networks. The collected industrial wastewater is subjected to conventional preliminary and primary treatment facilities including fine screening, grit removal and rectangular primary clarifier. This is followed by secondary treatment including anti-bulking reactor, aeration tanks and clarifiers. After passing through balance tanks, influents enter the tertiary treatment stage, which is comprised of sand filter, followed by chlorination system. This stage is followed by the quaternary treatment by reverse osmosis desalination process to reduce the salinity to acceptable levels.

6. Results of implementation of CWC in industrial cities

The implementation of CWC within the First and Second Industrial Cities of Dammam and Al-Hassa during the past 3 years has resulted in saving of about 28.72 million m^3/year of desalinated and transported seawater. This is in addition to saving of electricity consumption of about 855,742 MWh/year, which is equivalent of saving 1,608,555 barrels per year, worth about US$ 96.5 million at oil price of US$ 60/barrel.

7. Conclusion and recommendations

The successful experience of Saudi Arabia in full-scale treatment and reuse of industrial wastewater in industrial cities utilizing CWC has been attributed to successful adoption and execution of comprehensive and sound governance frameworks utilizing integrated water resources management tools since the beginning of the new century. The gained substantial benefits represented by savings of significant values of conventional fresh water resources, desalinated sea water, electricity and oil consumption has been a major step forward toward achieving sustainable water and energy security in the kingdom. The Saudi experience is a good model for other GCC and Arab countries to adopt for achieving sustainable water and energy security.