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APCBEE Procedia 10 (2014) 120 – 125

Procedia APCBEE

www.elsevier.com/locate/procedia

ICESD 2014: February 19-21, Singapore

Application of an Innovative Venturi Type Aeration Array as Part of the Restoration and Upgrading of an Obsolete Wastewater Treatment Plant

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Abstract

Wastewater treatment plants (WWTP) are usually planned for operational duration of several decades, nonetheless, at the end of that period and in many cases earlier, they need to be replaced. In the current project a typical extended aeration activated sludge facility have demonstrated high energy and labor consumption, as well as insufficient effluent quality. Since the option of replacing the WWTP was estimated in about 1.5 million USD, it was decided to try and rehabilitate it. The technical solutions applied included mainly a new aeration array with a reactive management system. Following this rehabilitation, the effluent quality became within the desired standards and with the new management system the energy consumption was reduced by about a half. Considering that the cost of implementing the new technical solutions was about tenth of the alternative, it is clear that for similar scenarios restoration of a WWTP is superior to building a replacement.

Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society

Keywords: Wastewater reclamation, Industrial wastewater treatment, WWTP fuzzy logic management, Aerobic digestion.

1. Introduction

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Selection and peer review under responsibility of Asia-Pacific Chemical, Biological & Environmental Engineering Society
doi:10.1016/j.apcbee.2014.10.028

The Middle East and most other sub-tropical and Mediterranean regions suffer from an ever-growing problem of accessing a sustainable water supply; as fresh water resources are either unavailable or approaching near-exhaustion. As a consequence, the agricultural and industrial sectors are becoming increasingly dependent on recycled sewage and other types of low-grade unpotable water. As a general rule, when the quantity of any given water resource is reduced the hazard of salination and of chemical or biological pollution, tends to increase; resulting in negative feedback and intensification of the problem [1]. Treating and reclaiming wastewater is typically performed using activated sludge in an extended aeration configuration. Since extended aeration systems are considered to be inherently efficient, there is little motivation for performance improvement, even when such systems suffer from overloading and from high energy consumption. While the overloading is usually avoided by strict maintenance of the facility, the high energy consumption is almost inherent to the traditional extended aeration design [2].

Wastewater can be classified according to their organic load or Biological Oxygen Demand (BOD) as untreated or raw (generally having a BOD > 300 mg/L or a high chemical load) or as treated. Treated is aqueous waste that has been treated to have a certain organic contaminant level: Grade A: BOD < 10 mg/L; Grade B: 20 < BOD < 150 mg/L; or Grade C: 150 < BOD < 300 mg/L, where only Grade A may be reclaimed. During wastewater treatment contaminants are removed to produce a liquid and a solid (sludge) phases, whereas the liquid phase in suitable for reuse discharge, e.g. being free of odors, suspended solids, and pathogenic bacteria. There are a number of typical stages of large-scale aqueous waste treatment. In an initial stage (primary treatment), the aqueous waste is clarified: floating solids and hydrophobic materials are removed, e.g., by raking or skimming, respectively, together with or followed by settling of sludge. In a following stage (secondary treatment), most of the organic contaminants in the liquid effluent from the initial stage are removed, typically by aerobic digestion using aerobic bacteria, to biologically oxidize organic contaminants. The resulting product settles as a coagulated mass (floc). To increase the rate of aerobic digestion, the aqueous waste is typically aerated during the aerobic digestion. If sufficient oxygen is present in the aqueous waste, aerobic digestion processes remove organic load faster than anaerobic and anoxic processes [3].

In most Wastewater Treatment Plants (WWTP), aqueous waste is aerated by forcing atmospheric air into the aerobic reactor using an aeration array. Until recently aeration arrays consisted mainly of coarse bubble diffusers and air lifts, in the last decade aeration arrays are mostly of fine to nano-bubble diffusers. In both cases the aeration array is placed at the bottom of the aerobic reactor. More recent, aeration arrays include membrane diffusers and jet aerators that may also be assembled from the surface into the aeration reactor [4]. In addition, modern aeration arrays are managed by a fuzzy feedback digital monitoring and control systems [5]. In the current project such control system with a Venturi Type jet aeration system [3] was applied, replacing the original obsolete air lift apparatus.

2. Materials and Methods

2.1. The Ariel West industry zone WWTP

The Ariel West industrial zone is located (32.096^{o},35.118^{o}) at the mountainous karstic terrain that overlays the major regional aquifer. Hence, the region is considered as having a high hydrological vulnerability [6] and A grade treatment is demanded. The original WWTP commences operating in 1991 and was intended to treat up to about 100 m3/day to B grade quality. When the project described in this paper started (10.2011) the daily influent was about 60 m3 and the demanded effluent quality was B grade (20 mg/l BOD and 30 mg/l TSS), presently the daily influent is greater than 100 m3 and the demanded effluent quality is A (less than 10 mg/l in both parameters). The WWTP consists of pretreatment for removal of flotsam, raking and coarse