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Treatment and reuse of industrial effluents: Case study of a thermal power plant

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Abstract

This paper presents a study of the potential of industrial wastewater reuse in Jordan's Al Hussein thermal power station. A comprehensive review of the processes involved, industrial waste generation and water requirements was carried out, and areas of potential improvment were identified. They include a water treatment system, blow-down system, flue gas desulfurization and finding alternative process water sources such as using sewage treatment plant effluent as make-up water. There is significant water pumped from the plant to the sewage plant and irrigation. Much of this wastewater could be treated by filtration, including reverse osmosis, and recirculated in the plant as process water. Water can very likely be conserved in the power plant by good operating practices such as preventative maintenance, good housekeeping, spill prevention, controlled storm run-off, cleaning techniques using minimum water, and a good training program to ensure program success. Since water conservation is very essential in Jordan, long-term plans should include consideration of changing the basic steam turbine technology to either the combined system or gas- and/or diesel-driven turbines at this power plant.

Keywords: Industrial effluents; Thermal power plant; Water conservation; Jordan

1. Introduction

According to the National Atlas of Jordan, the mean annual rainfall water in Jordan is 8500 Mm^3, of which only 1200 Mm^3 can be exploited. Seventy percent of this drains to the Jordan Valley, the Dead Sea and the Wadi Araba. The remaining 30% can only be utilized by drilling wells. Depletion of water sources and concentrated exploitation of main ground water basins have led to the depletion of many water reserves and deterioration of water quality. This is the situation in the Zarqa River basin. Intensive

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pumping has lowered the ground water table so that the river bed is dry most of the year and the main flow is wastewater effluent from the As Samra treatment plant (STP). At the same time, the salinity level has increased and the ground water in the upper strata is now polluted with all types of organic and chemical pollution [1–4].

The industrial sector in Jordan used 50 Mm^3 of water in 1998, which accounts for 5% of the total water consumption during this year. A major part of this was consumed by large industries such as phosphate mining; the production of potash, cement, ceramics and soft drinks; as well as the energy sector. Almost all local industries have suffered from shortages in water supplies during the last two decades. The water shortage is also the limiting factor for the establishment of new industries as well as the expansion of certain high water consumption processes such as oil shale processing [5].

In a recent paper, Mohsen and Jaber [6] discussed the potential of industrial wastewater reuse in Jordan. Industrial water requirements, wastewater production, types of pollutants in industrial wastewater and the technologies for wastewater treatment were evaluated. A total of 30 industries have been reviewed. The total effluent from these 30 industries was estimated at approximately 10,200 m^3/d. Of this amount approximately 4,400 m^3/d are discharged into the public sewerage system, which is about 3% of the total flow. The amounts of metals to be controlled are: 6800 kg/y, 3000 kg/y, 45 kg/y, 65 kg/y, 20 kg/y, 2 kg/y, 25 kg/y, 60 t/y and 8 t/y of Cr, Zn, Cu, Pb, Ni, Cd, Sn, Fe and Al, respectively. Nineteen industries, which discharge mainly organic polluted process wastewater, are mostly food industries. Approximately 5.3 t/d of BOD are discharged from these industries. Of these approximately 2.2 t/d BOD are discharged to the public sewerage system and about 3.1 t BOD are used for irrigation.

It has been shown that most of the selected industries require some treatment of their wastewater. It is recommended to carry out further studies to establish the type of wastewater pretreatment strategies and their estimated capital cost. There is a need for introduction of cleaner technology in the selected industries. This could include substitution of raw and auxiliary materials, water and energy saving, recirculation of water, recovery of chemicals, improved process control, waste minimization and good housekeeping.

Industry can be considered as a source of significant amounts of reusable effluents [7–10]. Thus, industry should be encouraged to invest in better water efficiency, more recycling and management. Normalized water use indices can be developed for each industry in order to allocate only as much water as necessary to achieve their production targets.

In this paper the potential of industrial wastewater reuse in Jordan's Al-Hussein thermal power station (HTPS) was investigated. A comprehensive review of the processes involved, industrial waste generation and water requirements was carried out. Areas of potential improvements and conservation have also been identified.

2. Industrial overview

Steam electric power plants are production facilities of the thermal electric power industry. A steam electric power plant product is electrical energy; its primary raw materials are fuel, air and water. Currently, four fuels are used in a steam electric power plant: three fossil fuels; coal, natural gas, and fuel oil; and uranium, the basic fuel of commercial nuclear power.

The commercial production of electrical energy requires the utilization and conversion of another form of energy. Present-day steam electric power plants utilize the chemical energy of