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Water recycling and reuse in soft drink/beverage industry: A case study for sustainable industrial water management in Turkey

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ABSTRACT

The aim of this study was to investigate water conservation and reuse opportunities in a soft drink/beverage manufacturing company. Water use analysis and benchmarking were carried out to determine the areas and processes where significant water saving potential is present. Based on evaluations, water recycling and reuse practices were realized in cooling systems. As a result of applying these practices, the total specific cooling water demand of the company was reduced from 14.4 to 1.2 m^3/m^3 product or by 91.8%. Moreover, the total specific water intensity of the company was decreased 55.0%. Thus, the achieved total annual water saving was 503,893 m^3. After applications, specific wastewater generation of the company was reduced by 57.4% and hydraulic overload issues in wastewater treatment plant of Kayseri organized industrial zone were resolved. During the implementation of water saving measures/techniques 56,960 $ was spent for equipments. Annual cost saving of the company were 97,000 $. So, the payback period of the implementations was approximately 7 months. This study proved that water recycling and reuse can successfully be implemented in soft drink/beverage industry as a sustainable industrial water management approach. If successfully replicated in other manufacturing sectors besides soft drink/beverage sector, outcomes of this study can be a solution for excessive cooling water consumption in Turkey as well as other parts of the world where similar processes are employed.

1. Introduction

As an emerging economy, Turkey is currently witnessing a rapid industrial development and associated excessive resource consumption. Being among the essential natural resources as well as indispensible inputs of agricultural, industrial and domestic activities, water resources are under increasing pressure. According to "Turkey Water Report", total water consumption in Turkey was increased 50.2% from 30.6 to 46.0 billion m^3 between 1990 and 2008 (MOEF, 2009). Projections indicate that between 2008 and 2030 total water consumption will increase almost threefold and become 112.0 billion m^3 (MOEF, 2008). During the same period (2008–2030), industrial water consumption is expected to increase tremendously or from 5 to 22 billion m^3. In other words, the share of the industrial water consumption will be expected to increase from 10.9 to 19.6% among agricultural and domestic uses in Turkey (MOEF, 2009). This trend reveals that although agricultural water use is by far the highest water consuming sector at present with a share of 70% of total water demand, industrial based development is subject to change it. Thus, serious measures should be taken in order to conserve water resources from depletion due to intensive industrial activities (Ulutas et al., 2011). The drastic changes in water quality and increasing territorial reduction of ground water level in Ergene Basin (in Thrace Region) due to intensive textile manufacturing activities can be given as an example for mismanagement in this area (Kaykıoğlu and Ekmekyapar, 2005). In order to prevent similar cases to happen in other areas of Turkey, the water intensive sectors should be targeted for water conservation.

In Turkey, one of the core industrial sectors relying on continuous and high quality water supply is food/drink industry which has been experiencing a remarkable rate of economic growth. The Federation of Food and Drink Industry Associations of Turkey states that annual added-value created by food/drink companies increased by 53.3% from 7.7 to 11.8 billion Turkish Lira (TL) between 2004 and 2009 (TGDF, 2011). Turkish food/drink industry has continued to grow even with a higher rate after 2009. In 2009–2012 period employment was increased from 338,852 to 406,091, an increase of 19.8%. During the same period export of food/drink products increased 61.0% from 5.9 to 9.5 billion $. In 2010, food/drink industry achieved an annual turnover of

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88.8 billion TL, which corresponds to 16.1% of total annual turnover (552.8 billion TL) generated in Turkish manufacturing industry (MOSIT, 2013).

Although food/drink industry is crucial for Turkish economy, its environmental impacts require particular attention. The primary impact of food/drink industry is on natural water resources. According to Turkish Statistical Institute, with a 131.2 million m^3/year it is responsible for 10.0% of total industrial water consumption (TSI, 2008a). Due to this high rate of water consumption food/drink industry placed in 3rd rank (after basic metals and textile products) among 23 manufacturing sectors in terms of water use. Furthermore, it exerts a great influence on receiving water bodies by discharging 76.3 million m^3 wastewater/year (TSI, 2008b). Besides water and wastewater issues, food/drink industry is among the highest solid and hazardous waste producer industries in Turkey. Producing 1.2 million ton/year of solid waste, it is responsible for 10.0% of total industrial solid waste generation which makes it 2nd biggest solid waste producer (TSI, 2008c). Based on hazardous waste generation quantity, food/drink industry is on 4th rank with a figure of 51.9 thousand tons/year (TSI, 2008d).

Since food/drink industry holds a water intensive and polluting character in Turkey, it was referred to in various policy and strategy documents to be treated as a priority sector for environmental protection (MOEF, 2010; IDA, 2012; Ulutas et al., 2012). The Ministry of Science Industry and Technology (MOSIT) underlined that steps are to be taken in the short-term to conserve natural resources and encourage waste recycling in the activities associated with the food/drink industry (MOSIT, 2013). Moreover, The Scientific and Technological Research Council of Turkey determined one of its targets as "protecting the environment by converting food/drink industry wastes into high added-value products" within the scope of "National R&D and Innovation Strategy: Food/Drink Sector" (TUBITAK, 2010).

In order to decrease water intensity and related environmental impacts as well as high costs associated with water and wastewater management in food/drink industry various water recycling and reuse techniques/technologies were implemented. According to Haroon et al. (2013) wastewater of soft drink/beverage industry can be reused in bottle washing and as boiler make-up water after treatment through a combination of reverse osmosis and ion-exchange systems. Another water treatment technology which is gaining much interest is ozonation. Owing to its powerful oxidizing and disinfection properties, ozonation is becoming more popular in food/drink industry for treatment and consecutive recovery of wastewaters (Norton et al., 2012). In a mandarin orange canning company, a water reclamation system composed of chlorination, filtration by active carbon and UV-sterilization was installed. The treated water is reused for segmenting, transportation and washing of fruits which led to substantial water saving in the company (Wu and Chu, 2013). In a non-alcoholic drink producer plant on the other hand, water pinch analysis was conducted after a water audit to identify water reuse opportunities. As a result of analyses recycling options were realized and this led to water saving of 83.2 m^3/day (Agana et al., 2013). According to Lozano et al. (2013) a chemical leasing study resulted in the elimination of water use in the lubrication process of a beverage company and the total water consumption of the company was reduced by 1500 m^3 annually. Cook et al. (2014) advocates that 37% of the non-potable demand can be satisfied by harvested rainwater in commercial buildings.

This study is expected to contribute to the efforts devoted to the sustainable exploitation of scarce resources particularly water sources which are under considerable risk due to climate change effects in Turkey (Alkaya and Demirer, 2015). The aim of this study was to investigate water conservation and reuse opportunities in a soft drink/beverage manufacturing company which relies on intensive water consumption in its production processes. For this purpose a walk-through audit was followed by analysis and benchmarking of water consumption of the company with the literature in order to determine processes/practices where significant improvement potential is present. After the diagnosis, the closed-loop water recycling systems and the practice of water reuse for fruit washing were introduced to save water and associated costs in the company. This study is expected to be a model for food/drink industry as well as other manufacturing industries for sustainable industrial water management.

2. Methodology

2.1. General information and production processes of the company

The company was established in 1969 in Kayseri, Turkey. It operates on a covered area of 15,000 m^2 and employs 100–130 workers depending on the season. Located in Kayseri Organized Industrial Zone, it currently produces soft drinks/beverages (Nace code: C.11.0.7 – Manufacture of soft drinks; production of mineral waters and other bottled waters). Major products of the company can be listed as: (i) 100% fruit juice (no additives), (ii) fruit nectar (25–50% fruit juice) and (iii) fruit drink (3–30% fruit juice). The company holds several quality and management certificates including "ISO 9001:2000 – Quality Management System Certificate", "ISO 22000 – Food Safety Management System Certificate" and "BRC – Certificate for Food Safety". Annual fruit juice production capacity of the company is 50,000 m^3/year.

Although production procedures/practices of the company change according to type of fruit to be processed and the products to be manufactured, a general process flow diagram could be developed as presented in Fig. 1. In the company, fruits are processed into soft drinks/beverages through two consecutive processing lines: fruit concentrate production and fruit juice production.

In 2008 and 2009 the company processed 14,658 and 10,888 tons of fruits, respectively. In 2009, processed major fruit type was apple with 4834 tons/year production. Grape, sour cherry and plum were other major types among 13 different types of fruits. The annual total soft drink/beverage production of the company was recorded as 36,009 and 38,761 m^3 for 2009 and 2010, respectively (no product information was provided by the company for the year 2008). In 2010, fruit nectars were the primary products of the company in terms of total production amount which was recorded as 30,795 m^3/year. Carbonated drinks (soft drinks with carbon dioxide) and 100% fruit juice drinks were other major products with 4335 and 2218 m^3/year manufactured amounts respectively. Remaining products are fruit juices with varying fruit contents including 50% fruit juice.

The fruits are first conveyed from storage to sorting/grading unit. The fruits are sorted before being further processed in order to assure that fresh, mature and unspoiled fruits are to be used. In this step fruits that do not meet the required standards are rejected. After sorting, fruits are washed where debris and dirt are removed. Then, the washed fruits are crushed in special mills which creates a type of fruit pulp puree. Crushing is followed by pressing for extracting the juice from the fruit pulps. This is the major solid waste generating operation in the company since spent pulps are rejected at this point. Extracted juice is concentrated in the evaporation step where water is drawn out. Before being sorted as the intermediate product, the concentrated juice is sterilized and filled into barrels through the aseptic process.

Concentrated juice is first fed to the dilution unit (water addition) in the fruit juice production line. Then, the diluted juice is filtered for clarification. After clarification, pasteurization process takes place where juice is subjected to heat. During this process