Qualitative monitoring of a treated wastewater reuse extensive distribution system: COD, TSS, EC and pH

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Abstract

During a five-month summer period, samples of tertiary treated wastewater flowing in an extensive distribution system composed of storage tanks and pipes, were collected at two-week intervals from 21 different sampling points, including the exit from the wastewater treatment plant (WWTP). The WWTP producing this effluent treated wastewater from one of the most popular European tourist resorts on the north coast of the island of Crete, at the southernmost point of Greece. Crete is a semi-arid region where 80 % of the freshwater resources are consumed by agriculture. More than 3 000 000 tourists visit the island during the summer period and the average summer equivalent population treated by the plant exceeds50 000, falling to under 5 000 in the winter. The samples were analysed for chemical oxygen demand (COD), total suspended solids (TSS), electrical conductivity (EC) and pH. The average COD and TSS in the WWTP exit were within the reuse limits for orchard irrigation, being 80 mg/ℓ and 25 mg/ℓ respectively. Both recorded higher values in the other sampling points, but still as an average below the above-mentioned limits. COD values along the distribution system presented a strong correlation with the WWTP's effluent quality, affected mainly by the condition of the collector, whereas TSS presented a completely different behaviour. EC and pH exceeded the optimum operation and reuse guidelines, mainly due to excessive septage in the WWTP. However, both presented a stable and predictable behaviour in correlation to the effluent quality, in terms of both distance and time, similar to that of COD. In terms of these parameters it is safe to suggest that, , achieving the required quality standards in the WWTP exit , the wastewater quality should be considered adequate for reuse for irrigation.

Keywords*:* wastewater; irrigation; distribution system; reuse; COD; TSS; EC; pH

Introduction

With a growing human population and continued improvement of quality of life, water resources are under stress both quantitatively and qualitatively. The world supply of freshwater is limited and threatened by pollution from various human activities. Rising demands for water to supply agriculture, industry and cities are leading to competition over the allocation of the limited freshwater resources (Gleick, 2002).

In Greece, it is estimated that water consumption is increasing by more than 3%/a.. The major water use in Greece is irrigated agriculture, and the island of Crete consumes approximately 268 x 10^6 m^3 annually (Angelakis et al., 1999; Tsanis and Naoum, 2003) for irrigation use only. The island also faces the major challenge of adequate water resources, especially during the summer when over 3 000 000 tourists visit the Crete (GNTO, 2005).

Given these developments, a large number of arid and semi-arid countries, including those in the Mediterranean region, are considering or already applying extensive wastewater reuse schemes, mainly for irrigation purposes (Shelef and Azon, 1996; Nurizzo et al., 2001). The success and public acceptability of this practice dictates the need for maintaining uncompromising, high-quality standards in any treated effluent and reclaimed wastewater which is reused. This is particularly important for the irrigation of food crops that are eaten raw, or public parks and sports fields (Tanaka et al., 1998; Armon et al., 2002).

Standards for wastewater reuse in many countries have been influenced by the World Health Organisation (WHO) Health Guidelines (WHO, 1989) and the United States Environmental Protection Agency (USEPA/USAID) Guidelines (EPA, 1992). The WHO Health Guidelines focus mainly on the presence of pathogens, while the Environmental Protection Agency (EPA) also includes physiochemical parameters such as organic load (BOD_5 or COD), TSS and residual chlorine concentration. The problem with treated wastewater sampling, which will eventually affect guideline establishment and monitoring, is the exact placement of the sampling point at which the quality standards must be achieved. Reuse licensing in Greece imposes quality standards on the wastewater treatment plant (WWTP) exit and not on the exact point of treated wastewater application. However, existing results have shown that the quality of treated wastewater deteriorates as it flows through distribution pipes, due to pathogen reactivation, pipe corrosion or external contamination (Shuval et al., 1973; Lindenauer and Darby, 1994; Higgins et al., 2002; Gehr et al., 2003).

In order to determine the most appropriate and reliable sampling point it is important to consider all data, whether produced in research laboratories and controlled environments or in real-life applications. The aim of this paper is to monitor such an actual application, in an extensive, operational tertiary treated wastewater distribution system, by correlating COD and TSS concentrations, as well as EC and pH values, with the effluent quality and downstream distance from the WWTP exit. The objective was to determine whether or not it is realistic to regard the effluent discharge point of a plant as the point where quality reuse standards should be imposed. The Port of

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Received 13 June 2005; accepted in revised form 22 September 2005.