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Water Research 39 (2005) 3035–3043

WATER RESEARCH

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Seasonal tertiary wastewater treatment in California: An analysis of public health benefits and costs

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Received 8 March 2004; received in revised form 21 April 2005; accepted 4 May 2005
Available online 23 June 2005

Abstract

A number of communities in the Central Valley of California have requested that seasonally based effluent limits be developed for their wastewater treatment facilities. These seasonal limits would be based on disinfected secondary treatment during the winter and disinfected tertiary treatment during the rest of the year. Such a request for seasonal limits raises a significant water quality policy question with regard to the costs and relative benefits of tertiary treatment during the winter season. A benefit–cost analysis for winter season tertiary wastewater treatment in California's Central Valley is presented here. The assumed societal benefit of winter tertiary treatment is enhanced water quality for recreational purposes, and thus reduced risk to public health. Based on the results of this analysis, between four and sixteen million recreation events would need to occur annually region-wide during the winter to justify the costs of winter tertiary treatment. A similar method and the information described herein could be used by the state water quality regulatory agency to develop a risk-based policy to consider seasonal limits.

Keywords: Wastewater treatment; Seasonal effluent limitations; Benefit–cost analysis; Microbial risk assessment; Water quality evaluation

1. Introduction

Approximately 43 communities in the Central Valley of California (Central Valley) have permitted dry weather wastewater discharges of over 10^9 L/d (500 Mgal/d) to surface waters. Several communities have requested wastewater discharge permits that would allow them to discharge the disinfected secondary treated effluent during the winter season and disinfected tertiary treated effluent during the rest of the year (seasonal limits).

The request for seasonal limits raises a significant water quality policy question with regard to the costs and relative benefits of tertiary wastewater treatment during the winter season. The benefit of tertiary wastewater treatment compared to secondary treatment is improved water quality of the effluent, and thus a

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doi:10.1016/j.watres.2005.05.010

reduction in the risk of illness when the receiving waters are used by the public. Recreation in receiving waters represents the highest potential for exposure to pathogens and was thus the focus of this investigation.

Water quality has been regulated in the United States for over one hundred years. The earliest regulations were established to protect public health and to increase navigability. More recently, water quality regulations have been extended to promote other goals such as fishable and swimmable waters and to restore and maintain the "chemical, physical, and biological integrity of the nation's waters" (US Congress, 1972). Numerical water quality objectives for recreational activities are almost always met by disinfected secondary effluents. However, regulatory agencies sometimes apply more stringent criteria to wastewater effluents to provide additional public health protection. California State law requires that economic factors be considered during such a decision process (CA Water Code sections 13241, 13263(a)).

Regulatory actions to address the potential risks associated with human exposure to microbiological contaminants in water are based on two distinct elements: risk assessment and risk management. In microbial risk assessment, data are used to define potential health effects associated with exposure to infectious agents. Risk management is the process of weighing different policies and selecting the most reasonable regulatory action, by integrating the results of the risk assessment with other important criteria such as engineering data and social, economic, and political concerns (National Research Council, 1983).

Assessment of the public health risk associated with exposure to pathogens in ambient waters is typically carried out by either (1) characterizing the risk associated with specific pathogens using microbial risk assessment techniques or (2) relating indicator organism densities to adverse health outcomes using epidemiological data. Waterborne infectious agents can be classified broadly under four groups: viruses, bacteria, protozoa, and helminthes. Pathogenic microorganisms, however, usually appear in recreational waters irregularly and in low concentrations (Cooper, 1991). Therefore, water quality monitoring programs tend to focus on indicator organisms rather than pathogen analysis. US EPA's water quality criteria for recreational waters are based on indicator organism densities and their relation to adverse health effects. EPA's own analysis suggests that the freshwater criteria correspond to a risk rate of 8–10 illnesses per 1000 recreation events (i.e., primary contact activities such as swimming, water skiing, surfing, and kayaking that could be expected to result in ingestion of the receiving water) and the marine water criteria correspond to a risk rate of 19 illnesses per 1000 recreation events (US EPA, 1986; US EPA, 2002).

The objective of the present study was to develop an analysis for the Central Valley, of the relative benefits and costs that result from providing tertiary treatment to wastewater discharges in the winter.

2. Methods

A benefit–cost analysis (BCA) approach is used to evaluate the relative benefit of adding tertiary treatment to existing secondary wastewater treatment facilities under two alternatives: (1) year-round tertiary treatment, and (2) tertiary treatment during the summer only. Capital and operations and maintenance (O&M) costs are estimated for both alternatives, and the marginal benefits associated with winter season tertiary treatment are derived and discussed.

2.1. Estimating capital and O&M costs for year-round tertiary treatment

Transfer analysis has been used to analyze environmental policy as it relates to natural resources (Bergstrom and De Civita, 1999). In transfer analysis, the economic risk, or impact predictions from an existing study are used to estimate similar predictions for another site (Desvousges et al., 1998); however the results of such an analysis are only as good as the original data and the conditions under investigation should be comparable (Brookshire and Neill, 1992). In this investigation a transfer method is used to assign estimated economic values to the cost of providing tertiary treatment to the Central Valley and Sierra foothills treatment plants. All treatment facilities are assumed to discharge to the surface waters in winter and human exposure to pathogens is assumed to occur via recreational activities with little dilution of the effluent.

Three representative communities recently received renewed discharge permits to continue discharging treated wastewater to freshwater streams in the Central Valley. In all three cases, the renewed permits required year-round tertiary treatment.

The City of Vacaville, California, approximately 70 km north of San Francisco, operates a 3.8×10^7 L/d (10 Mgal/d) wastewater treatment plant that is undergoing expansion to 5.7×10^7 L/d (15 Mgal/d). The estimated capital and the annual O&M costs to provide winter tertiary treatment for estimated winter peak plant flows of 10^8 L/d (27 Mgal/d) are \$13 million and \$1.2 million, respectively.

The El Dorado Irrigation District (EID), approximately 160 km northeast of San Francisco operates a 9.5×10^6 L/d (2.5 Mgal/d) treatment plant. The treatment plant produces tertiary disinfected wastewater during the summer and secondary effluent during the winter. The estimated capital and annual O&M costs to