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Pricing wastewater to save water: Are theory and practice transferable?

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ABSTRACT

Wastewater pricing by centralized utility systems enjoys little attention. Ongoing concern about water resource adequacy has prompted interest in deploying *wastewater pricing* to encourage *water conservation.* We emphasize that rate policy should be informed by an understanding of how essential water and wastewater services differ. Specifically, we ask whether a change in volumetric wastewater rates will induce a usage response like that anticipated for a comparable change in water rates. We observe that water is a resource input and wastewater is a byproduct of indoor water use that is largely nondiscretionary and unlikely to be very price-responsive.

1. Introduction

Compared to water pricing, wastewater pricing by centralized utility systems enjoys little attention. Pricing is a recognized tool for guiding efficient water consumption, primarily through the variable (volumetric) component of the rate structure. Ongoing concern about water resource adequacy has prompted interest in deploying *wastewater pricing* to encourage *water conservation.* In California, the idea was advanced in the wake of legislative requirements to reduce per-capita water demand by 20% by 2020 pursuant to the Water Conservation Act of 2009 (Senate Bill X7-7 or SB X7-7). A study commissioned by the Natural Resources Defense Council argued that a *mandated* movement to volumetric wastewater pricing, along with combined water and wastewater billing, would be equitable to ratepayers and result in significant water savings from conservation behavior (Chesnutt, 2011; NRDC, 2012).[1] This policy would constitute a striking change from current practice in California, where most centralized wastewater systems (even larger systems) do not charge volumetrically but instead impose fixed charges on residential wastewater customers (Table 1).[2] By comparison, most wastewater utilities across the United States incorporate volumetric usage into their tariffs (Table 2); the rationale for doing so appears to follow the accepted logic and conventions of water pricing. Interestingly, many U.S. water and energy utilities today are revisiting their reliance on variable charges for revenues in the context of persistent fixed costs and falling usage levels (NAWC, 2017; Proudlove et al., 2018).

The analytics motivating this paper may be case-specific, and thus not generalizable, but the recommended mandate and the assumptions that inspire it piqued our interest in exploring issues unique to wastewater pricing, particularly elasticity effects. While not arguing against the implementation of volumetric wastewater rates or combined water and wastewater billing, we emphasize that rate policy should be informed by an understanding of how essential water and wastewater services differ. We raise questions that may not have clear answers and for which more data and further research are needed. Specifically, we ask whether a change in volumetric wastewater rates will induce a water usage response like that anticipated for a comparable change in volumetric water rates (that is, a cross-elasticity effect). The answer depends on whether wastewater services exhibit comparable *and independent* price elasticity in the short and long terms, as might be presumed. These questions are of interest beyond California and the United States.

Residential wastewater services are not separately metered. Across the United States, user fees and charges, revenues from property and other taxes, and various combinations thereof support the cost of residential wastewater service. Community public health and sanitation goals, as well as equity considerations, may suggest a role for tax-based methods. When used, volumetric wastewater rates are usually tied to

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[1] The report estimated potential water savings by applying price elasticities for water use from a 1995 study to water sales and demographic data for the mid-2000 period. Water savings for the State of California are estimated "to be approximately 141 thousand acre-feet per year, with long-run pure price effects (over a 10–20-year time horizon) exceeding 283 thousand acre-feet per year" (3.2% and 6.4% annual reductions, respectively (Chesnutt, 2011)). We surmise that some of these savings may be illusory due to underlying modeling assumptions.

[2] Utility service providers of all kinds tend to favor rate structures that recover costs from fixed charges, to shield them from the effects of variable usage. By comparison, cost recovery from variable rates is favored by environmental advocates (to promote efficiency) and consumer advocates (to promote equity).

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Table 1
Summary of residential wastewater rate structures and billing methods in California (2016–2017).
Source: California State Water Resources Control Board, 2016-17 Wastewater User Charge Survey Report. The data exclude all "unknown" responses.

	Percentage of systems
All systems (n = 522)	
Rate structures	
Flat charge	75.3%
Flat charge plus variable charge	13.0%
Variable charge	11.7%
Total systems reporting	100.0%
Billing frequency	
Monthly	50.4%
Annual	32.8%
Bimonthly	14.4%
Quarterly	2.5%
Total systems reporting	100.0%
Systems serving populations of 50,000 or more (n = 127)	
Rate structures	
Flat charge	73.2%
Flat charge plus variable charge	10.2%
Variable charge	16.5%
Total systems reporting	100.0%
Billing frequency for systems serving populations of 50,000 or more (n=127)	
Monthly	39.4%
Annual	36.2%
Bimonthly	22.8%
Quarterly	1.6%
Total systems reporting	100.0%

Table 2
Summary of wastewater financial and ratemaking practices in the United States (2014).
Source: National Association of Clean Water Agencies (2015). Based on a sample of 111 utilities.

	Percentage of systems
Revenues	
User charges	59%
Debt financing (primarily revenue bonds)	18%
Taxes	6%
Federal and state grants and loans	4%
Reserves	4%
Assessments	4%
Hookup fees	3%
Other (including fees, interest, product sales)	2%
Rate structures	
Flat and volumetric charge	54%
Volumetric charge only	21%
Flat charge only	15%
Tax rate with flat or volumetric charge	10%

metered water consumption, resulting in some correlation. However, many utilities base wastewater bills on average off-peak season water use (or a percentage of the average) because while most indoor water use translates into wastewater flow, most outdoor usage does not. Pricing wastewater without adjusting for seasonality in water consumption disregards cost causality. In addition, based on the cost of service, it is not uncommon for wastewater charges to be greater than water charges for the off-peak level of usage, which will be more discernible to customers during the off-peak season.

Based on experience in the water sector, volumetric pricing for wastewater service may be regarded as consistent with the goals of efficiency and equity under cost-based ratemaking. More research is needed in this area to test the validity of this assumption and guide public policy. To the best of our knowledge, neither a theoretical nor an empirical basis for using wastewater pricing to induce water savings has been well established in the literature. In particular, despite considerable attention to the cost and behavioral economics of water pricing, the independent and incremental effects of wastewater pricing are indeterminate.

Water utilities have a variety of demand-management tools at their disposal, including volumetric pricing. Higher bills, due to price levels, rate structures, or combined billing, might magnify price signals but they will induce price-responsive behaviors *only to the extent that customers are willing and able to respond.* In this light, deploying volumetric wastewater pricing is a blunt instrument that may not be well rationalized or effective in achieving water conservation goals.

2. Dimensions of water and wastewater services

Notwithstanding parallels between the sectors, the uncritical transfer of pricing theory and practice from water to wastewater neglects relevant differences between these services and may be misleading. While the research literature on water pricing is considerable, there is far less information and insight about wastewater pricing and how it might be distinctive. Reviewed below are some key and interrelated dimensions of water and wastewater services that have implications for pricing.

2.1. Resource or byproduct

Water is a primary resource and an obvious input to potable water service, along with other resources needed for production and delivery. Potable water supply is constrained by available raw-water resources and infrastructure capacity for conveyance and treatment, which calls for deliberate supply and demand management. Microeconomic theory emphasizes that prices guide consumption decisions. Underpricing of water resources can lead to over-consumption and waste on the demand side, and thus stress on the supply side. In contrast, wastewater may be best understood as a *byproduct* of indoor water use. There is no wastewater without water; all wastewater comes from water already "used" (temporarily). Although not all water used goes down the drain, most of the water used indoors requires a form of sanitary disposal.[3] The economics of pricing a *resource* versus pricing a *byproduct* are fundamentally different. Economic analysis should consider the *net value* of wastewater that can be retained in the watershed and reclaimed for use as a local water supply resource (through recharging and reuse) as well as the opportunity for nutrient (such as phosphorus) and energy (biofuel) harvesting.[4] In other words, wastewater can be viewed as a renewable and potentially valuable resource to utilities.

2.2. Usage discretion

Residential water use is understood as a function of various demographic factors, as well as price. However, recent research attributes observed reductions in indoor water use more to the standards-driven efficiency of newer plumbing fixtures and appliances than to changes in occupancy or behavior (DeOreo et al., 2016; Mostafavi et al., 2018).[5] Outdoor usage will be shaped by irrigation area and weather (evapotranspiration). Water usage can also be differentiated according to consumptive behavior and water pricing can distinguish between less discretionary (less price responsive) and more discretionary (more price responsive) use. Wastewater usage is largely a function of a household's indoor water use. Controlling for the technological efficiency of water

[3] Alternatives to the centralized wastewater system are possible but may not be economical or permitted.

[4] Water reuse is considered more cost effective than desalination as a resource option, although both technologies may play a role in sustainability (Awerbuch and Trommsdorff, 2016).

[5] In the United States, water-efficiency standards for plumbing products were established by the federal Energy Policy Act of 1992. Potential energy savings are a prime rationale for water efficiency and conservation.