Structure and data requirements of an end-use model for residential water demand and return flow

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Abstract

An end-use model for residential water demand and return flow is presented in this paper. The model requires a unique description of a single residential stand in terms of all its end-uses. The end-uses include toilet flushing, bathing and showering, garden watering, pool water use, leaks, et cetera. Various parameters describe each of the end-uses. The model predicts five components relating to water use and wastewater flow at a residence: indoor water demand, outdoor water demand, hot water demand, wastewater flow volume and concentration of total dissolved solids in the wastewater. The large number of input parameters in an end-use model allow for powerful and detailed analysis of water demand. The various parameters required to populate the model are discussed, guideline values are presented and possible methods for calibration of the model to measured results are proposed. The model calculates 12 monthly results, for each of the five components, to provide a typical seasonal pattern as well as an annual value.

Keywords: water consumption - mathematical models, water salinisation, hot water supply

List of abbreviations and acronyms

AADC	=	average annual daily concentration of TDS (mg/ℓ)
AADD	=	average annual daily water demand (ℓ/stand·d)
AADF	=	average annual daily wastewater flow (ℓ/stand·d)
AADM	=	average annual daily mass (mg/stand/d)
AMDC	=	average monthly daily concentration of TDS (mg/ℓ)
AMDD	=	average monthly daily water demand (ℓ/stand·d)
AMDF	=	average monthly daily wastewater flow (ℓ/stand·d)
AMDM	=	average monthly daily mass (mg/stand·d)
a	=	binary flag to indicate whether the end-use is present/applicable (=1) or not (=0)
b	=	volume parameter (ℓ/event·quantity)
c	=	frequency parameter (events/person·d)
n	=	quantity parameter (household size, measured as the number of people per household)
d	=	days (average 30.44 d per month over the year)
e	=	end-use; refer to Table 1 for a list of end-uses pertaining to each model component
ET	=	evapotranspiration
f	=	garden irrigation factor, or factor for pool cover use
m	=	month (1 ... 12, or January ... December)
k	=	the empirical constant of proportionality between *p* and *ET* known as the crop factor (and it also represents the empirical constant of proportionality between *p* and the evaporation from the pool surface)
r	=	effective monthly rainfall (mm/month)
R	=	actual, or measured, monthly rainfall (mm/month)
p	=	pan evaporation (mm/month)
REUM	=	residential end-use model (described in this paper)
s	=	surface area of vegetation type, or surface area of pool water (m²)
t	=	actual mass of soluble substances added to water (mg/event)
u	=	wastewater return factor (0 for no return and 1 for 100% return of water)
T_B	=	blended ("desired") water temperature for end use *e* (°C)
T_C	=	cold water supply temperature $\approx$ ambient temperature (°C)
T_H	=	hot water supply temperature $\approx$ geyser temperature (°C)
TDS	=	total dissolved solids (mg/ℓ)
WDM	=	water demand management

and the subscript:

c denotes *cold water*
e denotes *end-use* (refer to Table 1)
h denotes *hot water*
i denotes *indoor*
m denotes *month* (1 ... 12, or January ... December)
o denotes *outdoor*
p denotes *potable water*
s denotes *soluble substance*
w denotes *wastewater.*

Introduction

As the national interest of water managers is shifting from traditional emphasis on supply management to water demand management (WDM), there is renewed interest in mathematical models that can predict the effects of new and even hitherto untried WDM measures. One such approach is end-use modelling, which has a rational rather than an empirical basis and which can therefore be used to model scenarios for which no historical data exists.

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