Batch test for characterisation of the carbonaceous materials in municipal wastewaters

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Abstract

As input to the current mathematical models for activated sludge systems, it is necessary to quantitatively characterise the influent COD. Existing methods are complex and time-consuming, or require activated sludge seed acclimatised to the wastewater, which may not be available. A batch test procedure is presented to quantify five influent COD fractions - unbiodegradable soluble (USCOD) and particulate (UPCOD), readily (RBCOD) and slowly (SBCOD) biodegradable, and heterotrophic active biomass (HAB). The method is relatively simple and does not require acclimatised activated sludge. For RBCOD and USCOD, results from the batch test correlate closely with those from conventional methods. However, for UPCOD and SBCOD, the correlation with conventional tests is poor, and the batch test estimates are not sufficiently accurate for design and simulation; this aspect requires further investigation. For HAB, the batch test estimates could not be evaluated as no conventional tests for this parameter are available.

Nomenclature

Abbreviations

AS	Activated sludge
BEPR	Biological excess phosphorus removal
BT	Batch test
F-RBCOD	Fermentable readily biodegradable COD
FFRW	Flocculated filtered raw wastewater
HAB	Heterotrophic active biomass
OUR	Oxygen utilisation rate
OUR_e	OUR for endogenous respiration
OUR_{syn}	OUR for biodegradable COD utilisation (heterotroph synthesis)
RBCOD	Readily biodegradable COD
SBCOD	Slowly biodegradable COD
SCFA	Short-chain fatty acids
UPCOD	Unbiodegradable particulate COD
USCOD	Unbiodegradable soluble COD

Symbols

f	Heterotroph endogenous residue fraction (mgCOD/mgCOD)
$f_{S,up}$	Fraction of total COD that is unbiodegradable particulate (mgCOD/mgCOD)
$f_{S,us}$	Fraction of total COD that is unbiodegradable soluble (mgCOD/mgCOD)
MO_C	Mass of oxygen consumed by heterotrophs over the batch test (mgO/ℓ)
S_{bi},S_{be}	Biodegradable COD concentration; influent/initial, end of test (mgCOD/ℓ)
S_{bpi}, S_{bpe}	Biodegradable particulate COD concentration; influent/initial, end of test (mgCOD/ℓ)
S_{bsai}	Short-chain fatty acid concentration; influent/initial (mgCOD/ℓ)
S_{bsfi}	Fermentable readily biodegradable COD concentration; influent/initial (mgCOD/ℓ)
S_{bsi}	Readily biodegradable COD concentration; influent/initial (mgCOD/ℓ)
S_{ti}, S_{te}	Total COD concentration; influent/initial, end of test (mgCOD/ℓ)
S_{upi}, S_{upe}	Unbiodegradable particulate COD concentration; influent/initial, end of test (mgCOD/ℓ)
S_{usi}, S_{use}	Unbiodegradable soluble COD concentration; influent/initial, end of test (mgCOD/ℓ)
Y_{ZH}	Heterotroph specific yield (mgCOD/mgCOD)
Z_{BHi}, Z_{BHe}	Heterotrophic active biomass; influent/initial, end of test (mgCOD/ℓ)
Z_{Ee}	Endogenous residue concentration; end of test (mgCOD/ℓ)

Introduction

To aid the design and operation of the single sludge activated sludge system, a number of steady state design models (e.g. WRC, 1984; Wentzel et al., 1990) and kinetic simulation (e.g. Dold et al., 1980, 1991; Van Haandel et al., 1981; Henze et al., 1987, 1995; Wentzel et al., 1992) have been developed, to progressively include aerobic COD removal and nitrification, anoxic denitrification and anaerobic/anoxic/aerobic biological excess phosphorus removal (BEPR). In terms of the framework of these design procedures and kinetic models, the influent carbonaceous material (measured in terms of the COD parameter) is subdivided into a number of fractions (Fig. 1): The COD of municipal wastewaters is divided into three main fractions, unbiodegradable, biodegradable and heterotrophic active biomass (HAB). The unbiodegradable COD has two subfractions, unbiodegradable particulate (UP)COD and unbiodegradable soluble (US)COD. The biodegradable COD also has two subfractions, slowly biodegradable (SB)COD and readily biodegradable (RB)COD. The RBCOD is further subdivided into two subfractions, short-chain fatty acids (SCFA) and fermentable (F-)RBCOD. Thus, for complete characterisation of a municipal

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