Journal of Hydrology (2006) 330, 155–170

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jhydrol

The water quality of the River Dun and the Kennet and Avon Canal

Colin Neal [a,*], W. Alan House [b], Helen P. Jarvie [a], Margaret Neal [a], Linda Hill [a], Heather Wickham [a]

[a] Centre for Ecology and Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OXON, OX10 8BB, UK
[b] Centre for Ecology and Hydrology, Winfrith Technology Centre, Dorchester, Dorset, DT2 8ZD, UK

Accepted 12 April 2006

KEYWORDS
Chalk;
Dun;
Kennet;
Thames;
River;
Water quality;
Nutrients;
Dissolved oxygen;
Farming;
Sewage;
Kennet;
Avon Canal;
Wilton Water

Summary The water quality of the River Dun and associated surface waters (a reservoir, two tributaries of the Dun, the Kennet and Avon Canal and the River Kennet to which the Dun drains) is described for a wide range of major, minor and trace elements. The water quality is determined by inputs from: (a) geologic sources (Ca, Sr concentrations and alkalinity) and (b) contaminant inputs from farming and sewage (Na, Cl, B, soluble reactive phosphorus and nitrate). As river water is mainly supplied from the Chalk aquifer and riparian areas, the water quality variation is damped, but there are occasional storms, where near surface/surface runoff delivers higher nutrient and suspended sediment concentrations, but dilutes determinands derived predominantly from geologic and point sources. River and canal water quality is also modified by in-stream biological processes in spring and summer, which remove nutrients (N, P and Si) and CO_2 from the water, bringing about precipitation of calcium carbonate and thus reductions in Ca concentrations and alkalinity. The biological effects are particularly marked for the Kennet and Avon Canal. The River Dun and Kennet and Avon Canal have been subject to episodic fish-kills and concern has been expressed about the role of event-based resuspension of bed sediments and mobilisation of dredged sediments on dissolved oxygen levels within the river. Therefore, fluvarium experiments on sediment–water interactions were undertaken to examine the potential effects of bed sediment disturbance on dissolved oxygen levels. The results of the fluvarium experiments demonstrate an ecologically-significant 30% reduction in dissolved oxygenissolved oxygen levels following bed sediment disturbance. This reduction in

* Corresponding author.
E-mail address: cn@ceh.ac.uk (C. Neal).

0022-1694/$ - see front matter
doi:10.1016/j.jhydrol.2006.04.017

DO concentrations was greater than expected from calculations using the measured sediment-oxygen demand. However, it is not clear that the bed sediments are mobilized to sufficient extent in the field for deleterious loss of DO. Indeed, much of the resuspended sediments within the canal and the river may well come from runoff from the land. The results also demonstrate key hydrogeochemical processes in Chalk-fed surface waters, with implications for environmental management.

Introduction

The maintenance of good water quality and ecological status within rivers, lakes and canals in lowland rural areas of the UK is of strategic importance for the sustainability of aquatic resources, rural economies and amenity value, especially with regards to issues of point and diffuse sources of nutrients, eutrophication and the control of excessive weed and algal growth (Jarvie et al., 1998; Mainstone and Parr, 2002; Withers and Lord, 2002). Further, the agricultural areas of the UK are primarily in the lowlands and they are important nationally in terms of the environment and socioeconomic factors.

While there has been much emphasis on rivers and lakes in relation to eutrophication and other water quality issues, canals can be an important part of lowland aquatic ecosystems. The canals of the United Kingdom were largely established during the industrial revolution that began over 200 years ago. The canals were of major economic value, linking mines, quarries, factories, mills, markets, major urban and industrial centres and deep-water ports (http://www.britishwaterways.co.uk/home/index.html). Now there are over 3000 km of such canals and their main usage has largely changed to that of leisure activity. There are growing issues of restoration of canals in the UK and there is developing research in terms of process understanding, hydrological, water quality and biological functioning (Rees and White, 1993; Pinkett, 1995; Struthers, 1997; Ruse, 1998; Swanson et al., 2004). Also, both inorganic and organic processes can lead to loss of nitrogen and phosphorus from the water column (House, 1990; Diaz et al., 1994; Shiratani et al., 2002). The inland waterways are worthy of environmental protection and scientific research within their own right, but there are also issues of their linkage to river courses, especially during low flow periods when there can be large interchanges in water. Indeed, there have been concerns over the effects that canals can have on river quality. For example, in the case of a tributary of the River Kennet (River Dun) in the Thames Basin to which the present study relates, a major pollution incident resulted in 150 tonnes of fish being killed in the river one year due to a toxic agent of microbial origin, linked to dredging activity, nutrient status and algal bloom collapse within the adjacent Kennet and Avon Canal (Johnson et al., 1998).

In this paper, the results of a hydrochemical study of the Dun system are presented. There are four reasons for this. Firstly, there have been clear environmental concerns for the Dun–Kennet and Avon Canal system. Secondly, many of the rivers and tributaries in the upper Thames Basin, which are Chalk-aquifer fed, have a history of water quality problems and associated biological deterioration (Bass et al., 1998; Jarvie et al., 2002, 2004) and there remain issues over why this should be. Most of these rivers do not have canals associated with them and the Dun system represents one of the key typologies within the Thames Basin (Neal and Whitehead, 2002; Neal et al., 2004a,b; Neal et al., 2005a,b; Neal et al., 2006a,b). Thirdly, there has been very limited research with respect to canal–river systems and their interactions with adjacent rivers. Fourthly, there is scientific merit in comparing the hydrochemistry of rivers and canals that are subject to similar groundwater inputs but which have different flow and temperature conditions. The paper comprises two parts. Firstly, the general water quality of the Dun system is described to set against the other research in the Thames basin and to complement an earlier paper which examined issues of phosphorus hydrochemistry within the Dun system. Secondly, laboratory studies are undertaken to examine if suspended sediments can result in oxygen loss from the water column and lead to water quality deterioration following dredging activities. The study forms a part of intensive research into the Thames Basin of south and south eastern England and the results are relevant to the thematic programme of LOwland CAtchment Research (LOCAR) to which this special issue is dedicated (Neal et al., 2004a,b).

Study area

The River Dun and Kennet and Avon (K&A) Canal are groundwater-fed from a major Chalk aquifer in the upper Thames basin and the catchment area is rural and characteristic of much of the Chalk-drained headwater stream areas of southern England. The upper reaches of the River Dun are fed by Wilton Water reservoir, which also supplies water to the adjacent Kennet and Avon Canal, an important waterway for boating and tourism (Neal et al., 2005a). The water of the River Dun is closely interlinked with the Canal, with interchange of water back and forth between the two.

The River Dun has a rural catchment of area about 101 km^2. Land use is dominated by mixed farming of cereal and other arable crops, permanent grass and livestock (cattle, pigs, sheep and poultry) and by tourism in relation to the K&A Canal. The underlying geology of the area is predominantly Cretaceous Chalk, which, as a major aquifer source, supplies most of the stream flow. Stream flow response to rainfall is highly damped (baseflow index 0.95; Marsh and Lees, 2003) due to this storage. Evaporation and transpiration is relatively high, with rainfall and runoff averaging 781 and 229 mm yr^{-1}, respectively. The Dun's flow starts near Wilton Water and then flows north-easterly