Computers and Electronics in Agriculture 96 (2013) 126–138

Contents lists available at SciVerse ScienceDirect

Computers and Electronics in Agriculture

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

Review

The impact of agricultural activities on water quality: A case for collaborative catchment-scale management using integrated wireless sensor networks

Huma Zia [a,*], Nick R. Harris [a], Geoff V. Merrett [a], Mark Rivers [b], Neil Coles [b]

[a] Electronics and Computer Science, University of Southampton, United Kingdom
[b] School of Environmental Systems Engineering, University of Western Australia, Australia

ARTICLE INFO

Article history:
Received 2 July 2012
Received in revised form 1 May 2013
Accepted 6 May 2013

Keywords:
Wireless sensor networks
Agricultural activities
Water quality monitoring and management
Catchment
Collaborative

ABSTRACT

The challenge of improving water quality is a growing global concern, typified by the European Commission Water Framework Directive and the United States Clean Water Act. The main drivers of poor water quality are economics, poor water management, agricultural practices and urban development. This paper reviews the extensive role of non-point sources, in particular the outdated agricultural practices, with respect to nutrient and contaminant contributions. Water quality monitoring (WQM) is currently undertaken through a number of data acquisition methods from grab sampling to satellite based remote sensing of water bodies. Based on the surveyed sampling methods and their numerous limitations, it is proposed that wireless sensor networks (WSNs), despite their own limitations, are still very attractive and effective for real-time spatio-temporal data collection for WQM applications. WSNs have been employed for WQM of surface and ground water and catchments, and have been fundamental in advancing the knowledge of contaminants trends through their high resolution observations. However, these applications have yet to explore the implementation and impact of this technology for management and control decisions, to minimise and prevent individual stakeholder's contributions, in an autonomous and dynamic manner. Here, the potential of WSN-controlled agricultural activities and different environmental compartments for integrated water quality management is presented and limitations of WSN in agriculture and WQM are identified. Finally, a case for collaborative networks at catchment scale is proposed for enabling cooperation among individually networked activities/stakeholders (farming activities, water bodies) for integrated water quality monitoring, control and management.

Contents

* Corresponding author. Tel.: +44 (0)23 8059 3234x23234; fax: +44 (0)23 8059 2901.
E-mail addresses: hz2g11@ecs.soton.ac.uk (H. Zia), nrh@ecs.soton.ac.uk (N.R. Harris), gvm@ecs.soton.ac.uk (G.V. Merrett), mark.rivers@uwa.edu.au (M. Rivers), neil.coles@uwa.edu.au (N. Coles).

0168-1699/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.compag.2013.05.001

1. Introduction

Water is a key natural resource which is vital for the survival of all ecosystems on the planet. However, less than 1% of the earth's water resources are accessible to humans as fresh water, in the form of either surface or ground water (Krchnak et al., 2002; UNESCO, 2006). Although there is currently sufficient water for essential activities (Blanco et al., 2009) including drinking, irrigation, and domestic and industrial use on a global scale, the spatial distribution of water suggests that, in many cases, it is not available where it is required. Because of the unequal distribution of fresh water resources, billions of people around the globe live in water-stressed and water-limited environments. Therefore it is crucial to preserve water resources although in practice it is continually degraded and depleted owing to inappropriately targeted funding initiatives leading to poor water management, redundant and outdated agricultural practices and urban development (Rosegrant et al., 2002; Verhoeven et al., 2006).

The key issues relating to global freshwater quality problems in the environment and public health are summarised as (FAO, 1996):

(1) Non-economic cost of drinking water treatment.
(2) Millions of annual deaths resulting from water-borne diseases.
(3) Ecosystem dysfunction and loss of biodiversity.
(4) Contamination of marine ecosystems.
(5) Contamination of groundwater resources.
(6) Depletion of usable water resources.
(7) Deterioration of recreational activities.

Problems associated with water quality are commonly attributed to nutrient, chemical and pathogen loadings into an aquatic system as a result of point source and non-point source activities (EPA, 2009). Discharges from point sources are identifiable and come from a single source. Examples include contaminants from sewage plant pipes or industries. On the other hand non-point source fluxes may come from diffused sources/activities with no direct source of

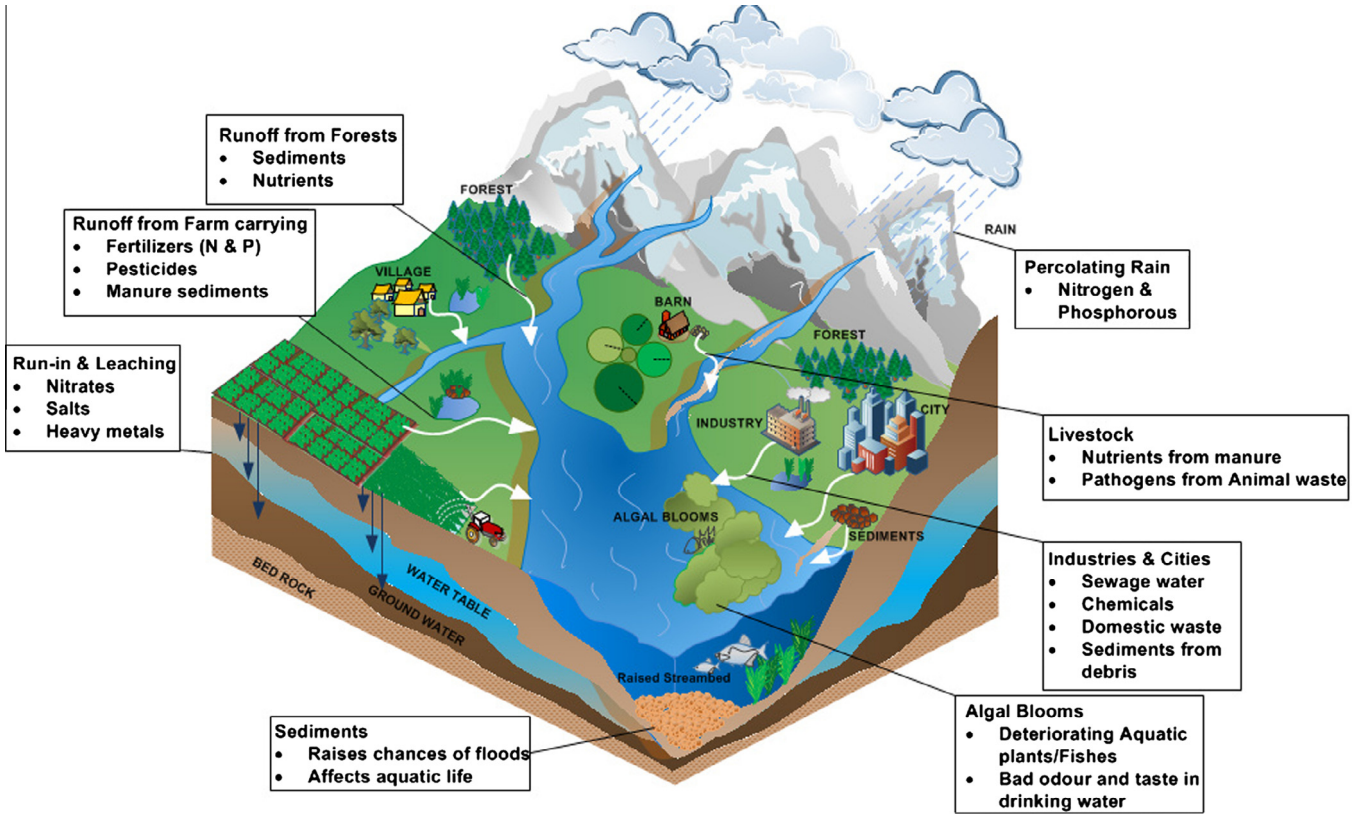

Fig. 1. Water contamination activities in a catchment.