Sustainable groundwater use, the capture principle, and adaptive management

Paul Seward[1]*, Yongxin Xu[2] and Luc Brendonck[3]
[1]*Department of Water Affairs and Forestry, Bellville, South Africa*
[2]*Department of Earth Sciences, University of the Western Cape, Bellville, South Africa*
[3]*Laboratory of Aquatic Ecology, K.U. Leuven, Ch. de Bériotstraat 32, B-3000 Leuven, Belgium*

Abstract

The purpose of this paper is to review the case for using 'capture' rather than recharge as the conceptual basis for sustainable groundwater use in South Africa. Capture refers to the sum of the increase in recharge and decrease in discharge brought about by pumping. Definitions of sustainability are reviewed, and the capture process is outlined. Implications for using the capture principle in the implementation of the NWA are discussed, and adaptive management is proposed as an appropriate management approach. Implications for groundwater monitoring are also discussed. Case studies are described that support the need for adaptive management and the application of the capture principle.

Keywords: groundwater, capture, sustainability, safe yield, recharge, adaptive management, monitoring

Introduction

Key thrusts in South Africa's National Water Act of 1998 are sustainability and equity, encapsulated in the slogan 'some for all for ever.' Numerous tools are provided by the Act to facilitate sustainability and equity, although defining sustainability is not one of them. Ensuring sustainability in the groundwater field poses a number of challenges. Not the least of these challenges is how to interpret the concept of sustainability – an issue that appears to be poorly understood as far as groundwater is concerned.

Equating groundwater sustainability to average annual virgin recharge appears to be endemic. The central argument of this paper is that it is conceptually incorrect to define sustainability (or safe yield) by average annual (natural) recharge. It is further argued that it is also conceptually incorrect to assume that recharge minus the Reserve (aquatic ecosystem requirements and basic human needs) gives an amount of groundwater that can be sustainably allocated. These arguments are not new. Theis (1940) has already explained how sustainable groundwater use is dependent on increased recharge, and/or reduced discharge, rather than natural recharge. This increased recharge and/or reduced discharge has been termed capture (Lohman, 1972). What is new is the managerial **application** of the capture concept in South Africa. An internet search failed to reveal any South African pages containing the capture principle in a groundwater context, while many hundred pages were found that contained both groundwater and recharge, or groundwater and water balance.

Case studies are given to illustrate why natural recharge is an inappropriate basis for determining sustainable groundwater use, and why the capture principle should be used instead. The case studies also explore the need for an adaptive management approach, and are used to suggest appropriate monitoring strategies.

Sustainability – Historical background

The classic definition of sustainable development in general, given by the Brundtland Commission (World Commission on Environment and Development, 1987), is *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'*

Similar concerns for the present and the future in the water resources management field are given by Loucks (2000) who states that: '*Water resource systems that are managed to satisfy the changing demands put on them, now and on into the future, without system degradation, can be called 'sustainable.''* The demands placed on the resource include the objectives of society, as well as ecological, environmental, and hydrological integrity (Loucks and Gladwell, 1999).

These definitions of environmental sustainability only really began to emerge in the past few decades. However, sustainability's forerunner – safe yield – has been used in groundwater for nearly a century. In the 'journey from safe yield to sustainability' Alley and Leake (2004) trace the first definition of safe yield back to Lee (1915) who defines safe yield as the quantity of water that be pumped 'regularly and permanently without dangerous depletion of the storage reserve.'

In the ensuing decades issues outside the purely hydrological definition of Lee were added, leading to Todd (1959) defining the safe yield of a groundwater basin as 'the amount of water that can be withdrawn from it annually without producing an undesired effect.' According to Todd (1959) four factors are usually considered when determining safe yield:

1. **Water Supply:** This can either be the recharge to the basin, or the rate of movement of groundwater through the basin, whichever is the lesser.
2. **Economics:** Excessive pumping may lower water levels to such an extent that the use of groundwater is no longer economic. In such cases the safe yield hinges on specifying maximum borehole yields or minimum water levels.

* To whom all correspondence should be addressed.
☎ +2721 950 7100; fax: +2721 950 7150;
e-mail: sewardp@dwaf.gov.za
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