

Practical experiences with granular activated carbon (GAC) at the Rietvlei Water Treatment Plant

Michele Clements and Johannes Haarhoff

Water Research Group, Rand Afrikaans University, PO Box 524, Auckland Park 2006, South Africa

Abstract

The Rietvlei Water Treatment Plant was extended with a granular activated carbon (GAC) filtration system after an exhaustive series of tests, which were started in 1994. Upon commissioning towards the middle of 1999, a year of close monitoring followed to measure the GAC performance at full-scale. After verification that the GAC does indeed ensure a high quality product under all conditions, the emphasis shifted to the optimisation of the GAC handling and regeneration system. Frequently moving the entire GAC inventory from the filters to an off-site regeneration plant and back requires significant operational effort and contributes a major part of the total cost of the GAC system. A number of systematic investigations were carried out in response to a number of practical questions that arose at Rietvlei. The first part of the study was directed towards tracking and quantifying the GAC on and off site. The main findings were that 10.0% of the GAC is lost from the filter during backwashing (0.3%) and removal of GAC from the filter for regeneration (9.7%). The sump does not trap all this GAC and 2.3% of the total inventory is lost to the river. Inserting a sieve at the outlet of the sump can eliminate this loss. A further 80.3% of the GAC in a filter is removed for regeneration, of which 18.7% is lost during the regeneration process. The minimising of this loss can only be achieved through the optimisation of the regeneration process, which falls within the domain of the regeneration contractor. The second part of the study was directed at the behaviour of the GAC whilst within the filter bed. The porosity and sphericity were determined by laboratory tests and calculations. The porosity was found to be 0.69 for the 12 x 40 size carbon and 0.66 for the 8 x 30 size carbon. By using a calibrated bed expansion model, bed expansion could be calculated at 9°C and 23°C for the two carbon gradings; the maximum temperature range experienced at Rietvlei. The main finding of this part of the study was that the average available freeboard is 650 mm for the 12 x 40 grading and 430 mm for the 8 x 30 grading, and therefore no GAC should wash over the weir at all during backwashing. The third part of the study measured the physical changes of the GAC found at different points in the GAC cycle. The main findings were that the small fraction of GAC washed out of the bed during backwashing and removal has a finer grading, higher apparent density and lower adsorption capacity than the GAC in the filter bed. There seems to be no marked attrition of the carbon or generation of fines during the removal and transport of the GAC to the regeneration plant. After regeneration, there was a 7.0% decrease in apparent density and a 30.0% increase in adsorption capacity. The final part of the study correlated the adsorption capacity of the GAC with its time in use as well as UV254 removal. After regeneration, UV254 removal begins at approximately 20.0% and declines to 14.0% after 400 d of operation, and to 10.0% after 600 d. After regeneration, the iodine number begins at approximately 800 g/mg, declines to 600 g/mg after 400 d of operation, and to 500 g/mg after 600 d.

Keywords: granular activated carbon, regeneration, bed expansion, backwashing, abrasion, apparent density

Introduction

Rietvlei Dam, situated on the Hennops River, has been supplying the city of Pretoria with drinking water since 1934. Through the years the population around the Hennops River has grown, and the quality of the water in the dam has deteriorated. For this reason the water treatment plant was upgraded in 1988, which improved the performance of the plant for some years. Because of extensive agricultural activities in the catchment area, increasing concentrations of nitrogen and phosphorus flowed into the dam, which increased the growth of algae.

Van Staden (1996) did a pilot-plant study for 192 d on different auxiliary treatment possibilities at Rietvlei. Granular activated carbon (GAC) and ozone possibilities were investigated. His results indicated that an auxiliary GAC plant would be the optimum choice when considering the economics and quality of the water. To eliminate the taste and odour caused by the algae, the GAC plant

was built and commissioned on 22 November 1999. Upon commissioning, a year of close monitoring by De Kloe (2000) followed to measure the GAC performance at full-scale. After verification that the GAC does indeed ensure a high quality product under all conditions, the emphasis shifted to the optimisation of the GAC handling and regeneration system.

The initial indications were that the GAC losses are higher than originally expected, and that most of these losses occurred during the regeneration cycle. If these losses could be reduced, and the GAC regenerated less frequently, the operational costs could be sharply reduced. As the GAC plant at Rietvlei is the only working plant of its kind in South Africa, there is an absence of local data on the expected losses during plant operations, handling and regeneration of the GAC. This paper therefore addresses a number of systematic investigations carried out in response to the following practical questions that arose at Rietvlei:

- How large are the GAC losses? Can these losses be identified and quantified?
- How does the GAC behave *in situ* in the filter beds?
- How is the GAC changed during the regeneration cycle?

* To whom all correspondence should be addressed.

☎ +2711 489 2354; fax: +2711 489 2148; e-mail: mcl@ing.rau.ac.za
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