*Technical note*

# Measurement and expression of granular filter cleanliness

**Johannes Haarhoff and Samantha van Staden***

*Department of Civil Engineering Science, University of Johannesburg, PO Box 524, Auckland Park 2006, South Africa*

## ABSTRACT

The problem of dirty filter media at water treatment plants, despite having good backwash systems, is a serious challenge that requires constant monitoring and maintenance. To aid the systematic analysis of filter media and the troubleshooting of problem filters, this paper firstly proposes a standard procedure for quantification of the specific deposit on filter media, including tentative guidelines for the interpretation of the results. Secondly, a standard procedure is proposed for the characterisation of the specific deposit, based on its volatility and its acid solubility. These fractions are helpful to trace the origin of excessively dirty filter media. Thirdly, the utility of the proposed procedures is demonstrated by the results of a South African treatment plant survey. This confirms some earlier observations that there often is a real problem with recalcitrant specific deposits that cannot be readily removed by backwashing, a fraction that correlates with the organic fraction in the specific deposit.

**Keywords:** backwashing, specific deposit, filter media, filter cleanliness

## INTRODUCTION

Filtration theory suggests that a sand filter starts its life with new, perfectly clean media. During each filtration cycle, its media pores become gradually clogged as the particles are trapped, forming specific deposit. When the specific deposit builds up to a point where either the head loss or the filtrate quality reach their acceptable limits, the backwash cycle is initiated. The combined action of air and water quickly returns the media to its original perfectly clean state, and so the cycle continues.

The reality is different. It is common practice to return to a treatment plant a decade or more after its commissioning to find filter sand that is unacceptably dirty, with backwash systems that are clearly incapable of cleaning the media to its initial state of cleanliness. Frequently, it is easy to pinpoint the source of the problem – faulty design, substandard construction practices, gross negligence of operators, well-meant but disastrous attempts to correct earlier problems, etc. These problems have been systematically reviewed in a previous publication (Lombard and Haarhoff, 1995). However, in a significant number of cases, the reasons for the media deterioration remain elusive. The design, construction and operation seem to be on par with the best international practice, yet the media steadily becomes dirtier and dirtier.

Excessively dirty filters are identified when mudballs are evident in the media bed. The eminent John Baylis of Chicago stated as early as 1935 that 'mud balls and clogged places in rapid sand filters are the cause of more filter bed trouble than any other single thing' (Baylis, 1935a). In the same year, he published a method for measuring the mudball volume in a filter bed, with guidelines for its interpretation (Baylis, 1935b). If the mudball volume is below 0.1% of the media volume, the condition of the filter bed could be considered 'excellent'; above 5.0% the condition would be 'very bad'. It was shown that mudballs start to grow around sand grains with low specific gravity of about 1.2, but as they grow, the material compacts and becomes a real problem when the specific gravity reaches about 1.6 – a point where they cannot readily be washed out. Early mudball formation indicated by small mudballs can thus be most commonly seen after backwashing in the top 150 mm of a bed. Older, larger mudballs are heavier and sink to positions of low upward velocity in corners and along walls (Hudson, 1981).

A likely argument is that the detection of mudballs already indicates an advanced state of media deterioration. Could one not get an early warning **before** mudballs can be detected? To do this, a more sensitive procedure is required which will strip and quantify the thin layer of specific deposit from the media grains before mudball formation. Such a method was proposed by Kawamura (Kawamura, 2000). He provided a detailed procedure for sampling a media bed, as well as stripping the specific deposit by vigorous shaking of the media in the presence of water. The turbidity of the water decanted off the media is then used with a 4-point scale for assessing filter cleanliness – clean, slightly dirty, dirty with need for closer evaluation, and problems with mudballs. The procedure was called the 'mud retention analysis' and 'sludge retention analysis'. To encourage more systematic filter assessment and maintenance, a comprehensive guidance manual was published shortly thereafter, which incorporated the Kawamura procedure, labelled as the 'floc retention analysis' (Logsdon et al., 2002).

In South Africa, problems with dirty filter media are commonly experienced, exacerbated by highly eutrophic surface water at high temperatures. These conditions are conducive to the formation of biofilm in the filter media, which had been conclusively shown to inhibit the effective backwashing of sand and carbon filters (Clements, 2002). A systematic investigation into filter media cleanliness was therefore started around 2002 at the University of Johannesburg (up to 2004, the Rand Afrikaans University). This paper provides some pertinent findings of this work regarding:

* To whom all correspondence should be addressed.

☎ +27 11 559 2395; e-mail: samvs@uj.ac.za

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