Microbiological survey of open recirculating cooling water systems and their raw water supplies at twelve fossil-fired power stations

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Abstract

Raw water supplies utilised at 12 fossil-fired power stations, as well as the corresponding open recirculating cooling water systems were surveyed. Visual inspections were carried *out* and total aerobic and anaerobic bacteria, anaerobic acid-producing bacteria, *Thiobacillus* spp., *Nitrobacter* spp., sulphate-reducing bacteria (SRB) and algae were quantified. All raw water supplies and recirculating cooling waters contained all of the above groups of micro-organisms, with the exception of the two potable raw water supplies. In 75% of the systems, the numbers of SRB in the recircuiating cooling waters were higher than in the corresponding raw water supplies and in 92% of the systems, the numbers of total aerobic bacteria were higher in the recirculating cooling waters than in the raw water supplies. However, no relationship between the sulphate levels in the recirculating cooling waters and the numbers of SRB could be distinguished, or between the percentage increase in the numbers of total aerobic bacteria and the cycles of concentration at which the system was operated. The frequency polygons of the occurrences of total aerobic and anaerobic bacteria in the raw water supplies and recirculalJng cooling waters did not follow normal distribution patterns. Visible biofouiing deposits were observed at six of the power stations surveyed and the predominant algal group was the blue-green algae. However, in the raw water supplies, the predominant algal groups were green algae and diatoms. Microbiologically influenced corrosion was identified in all five of the condensers inspected. Each system was found to be unique and no generalisations in terms of presence or activity of micro-organisms could be made.

Introduction

The Department of Water Affairs and Forestry of South Africa has requested that dry-cooled power stations be constructed preferentially, as this type of power station utilises only 22% of the volume of water required by a wet-cooled station. Higher capital expenditure is, however, required for the construction of dry-cooled stations and operating costs are also elevated when compared with wet-cooled power stations. It is therefore possible that wet-cooled power stations may still be constructed in the future. It is estimated that by the year 2010, a total of 900 x 10^6 m^3 /a of water will be required for power generation, as compared with the 282 x 10^6 m^3 of water consumed during 1980 (Anon, 1986). Thus the need for water conservation and reuse will be of extreme importance in the future.

Awareness of microbially related problems in open recirculating cooling water systems has increased over the last *few* years and has been extensively reviewed (Soracco et al., 1988; Cloete et al., 1992). It has been widely reported that in aqueous systems, micro-organisms attach themselves to available surfaces by means of extracellular polymers, forming biofilms or biofouiing deposits (Duddridge and Pritchard, 1983; Characklis et at, 1990). The attachment of micro-organisms to surfaces enables them to function as a multicellular tissue (Costerton et al., 1987). The physical presence of such deposits in cooling water systems can result in decreased heat transfer and increased frictional resistance (Characklis, !973;Ferguson, 1981). Inaddition,discretemicrobial colonies within biofilms or biofouling deposits on metal or concrete structures, can give rise to microbiologically influenced corrosion (MIC). The major groups of micro-organisms responsible for this phenomenon are the sulphate reducing bacteria (SRB), aerobic acid producing bacteria such as *Thiobacillus* spp. and *Nitrobader* spp., anaerobic acid producing bacteria such as *Clostridium* spp. and iron bacteria such as *Gallionella* spp. (Tatnall, 1981; Pope et al., 1988). Algae are also responsible for numerous problems in cooling water systems, for example, reduction in heat transfer across cooling towers (McCoy, 1980).

Due to the intensified demand on limited water resources for a wide variety of industrial and domestic uses, the quality of water supply in South Africa is degenerating (Anon, 1986). The incidence of MIC and biofouling in industrial water systems in South Africa is increasing, resulting in costly control programmes and down-time (Poulton and Nixon, 1990). Iverson (1987), estimated that MIC constituted 10% of all metallic corrosion while the estimated direct cost of MIC in South Africa is approximately R400 million (Von Holy and Cloete, 1988). As the presence of potentially troublesome groups of micro-organisms can have profound effects on cooling water system operation and integrity, it is essential to determine their presence, activity and source.

The aim of this study was therefore to survey open recirculating cooling water systems at 12 fossil-fired power stations and their corresponding raw water make-up supplies. It was anticipated that this survey would not only reveal the extent of microbial contamination in these systems, but would also indicate which make-up supplies contained undesirable micro-organisms.

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