ABSTRACT

This study investigates the effectiveness of chlorine as the disinfectant employed in the wastewater treatment plants operated by Lepelle Northern Water and generally within most municipal wastewater treatment works. The literature review reveals that much of the chlorine demand is ultimately wasted, since reactions competing with the disinfection process results in the formation of chloramines and other by-products not related to chlorine's primary purpose of inactivating micro-organisms in the water. The investigation focused on the following aspects:

- The impact of chlorine and wastewater contact time and chlorine residual concentration on micro-organism inactivation while reducing chlorine dose and aiming not to meet chlorine demand.
- The impact of mixing on the effective disinfection of effluent at the point of chlorination.

Literature shows that although various alternatives to chlorine are available, chlorine remains user-friendly and the cost-effective option for the disinfection of wastewater.
The formation of chlorine residual in sewage effluent for inactivation of bacteria and prevention of regrowth is not as necessary as it is in drinking water systems where the chlorine residual has to be maintained throughout the distribution system. It is therefore a wasteful exercise to satisfy the chlorine demand in wastewater (sewage) effluent discharged into water courses. It is also worth noting that the only purpose of chlorine in wastewater effluent disinfection is to inactivate microorganisms. There is no need to prevent the recontamination of water since the effluent in most municipal sewage treatment plants are immediately discharged into a water course and the chlorine residual in the effluent must not be detected since it is toxic to aquatic life. This study therefore examines the potential disinfection effectiveness of chlorine without meeting chlorine demand or reaching breakpoint chlorination and mixing at the point of chlorination.

The results obtained from a full-scale wastewater treatment plant effluent quality monitoring programme were used as baseline information and reference for this study.

By comparing the observed micro-organism (that is; E. coli) inactivation in the full-scale chlorine systems with E. coli inactivation determined under laboratory conditions, it is conclusive in the literature that chlorination in practice appears to be much less effective than could be expected under

laboratory conditions. In the literature, one study shows that suboptimal hydraulics of full-scale systems are known to reduce the efficacy of inactivation in practice. However, this study indicates that when mixing is applied at the point of chlorination, significant and comparable inactivation can be achieved at a full-scale and at a laboratory scale. This was confirmed in another study which reported rapid initial E. coli inactivation upon contact with free chlorine. Therefore, when a specific optimal mixing regime is determined and applied at the point of chlorination, effective E. coli inactivation in the water is achieved irrespective of the kinetics applicable either at a laboratory scale or in a full-scale system.

This study examines the potential disinfection effectiveness of chlorine without meeting chlorine demand or reaching breakpoint chlorination and mixing at the point of chlorination. The results obtained shows that E. coli inactivation occur at two rates, an initial rapid kill followed by a slower kill. For each applied chlorine dose, the highest inactivation rate was obtained during the first one minute of contact time, which could be due to the presence of free chlorine residual that had not yet reacted with chlorine demanding substances (organics and chemicals). The subsequent slower kill can possibly be attributed to the formation of less potent combined chlorine residual as a result of reactions between free chlorine residual and chlorine demanding substances (mainly NH_3).
This study revealed that rapid mixing of chlorine with wastewater may achieve the required degree of disinfection by using less chlorine, and this will result in significant savings in chlorine dosing. This proposition was confirmed in this study by tests conducted in a full-scale investigation, where the chlorine dosage required to inactivate E. coli at the Burgersfort WWTW effluent was reduced by 50% from the mode of 6.43 mg/l before mixing to the mode of 3.0 mg/l after mixing.

For effective chlorination, a disinfection system must be designed within wastewater treatment works for the wastewater to flow turbulently throughout a chlorine contact chamber and/or dosing point in order to achieve complete mixing within 1 minute of contact time. The mixing allows the maximum dispersal of the free chlorine in the wastewater and contact between chlorine and the microorganisms in the effluent. This ensures effective inactivation before the free chlorine reacts with other impurities present in wastewater that demand chlorine.