Activated Sludge Treatment of Paper Mill Effluents

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Introduction

The pulp and paper industry is the second largest industrial water consumer in Europe with a usage of 35 m3/ton paper and a production of 85.2 M tons/year. Its effluents cause considerable damage to the receiving waters if discharged untreated since they have a high biochemical oxygen demand (BOD), chemical oxygen demand (COD) and contain chlorinated compounds, suspended solids (mainly fibres), fatty acids, lignin, and sulphur compounds. Environmental legislation has affected the pulp and paper industry. A number of UK mills are authorised under Integrated Pollution Control (IPC), so they have to demonstrate that they are using best available techniques not entailing excessive cost (BATNEEC) to control emissions to the environment. The use of primary treatment followed by secondary biological treatment, which is the approach adopted by UK mills, is considered to be BATNEEC for the industry.

Research Proposal

The most widely used secondary treatment process adopted by the UK paper mills, is activated sludge. A project team has been formed to tackle the problems, which have been encountered at a paper mill. Based on discussions with Kimberly-Clark and PIRA International it is envisaged that the PhD programme would examine the potential effect of the "dirty" stream on the operational performance of the Flint wastewater treatment plant (Figure 1). Bench scale studies (Plate 1) will be undertaken to test the effects of influent composition and environmental factors.

Literature Review

Activated sludge process was first introduced in the United Kingdom, as a municipal wastewater treatment technology, in 1914 and its basic design has remained unaltered since then. It is an aerobic biological process in which wastewater is treated with micro-organisms. It can be divided into two sections: the aeration tank and the settlement tank or clarifier (Figure 2). Within the aeration tank the wastewater is contacted with an aerated mixed culture of microbes, which are in a well-flocculated state. During this contacting period the dissolved organics are removed and transported into the microbial cells. In the settlement tank, the activated sludge is separated from the liquid phase by sedimentation and recycled to the aeration tank, in order to maintain a high concentration of biomass. The activated sludge will continue to build up until it is necessary to waste some of the excess.

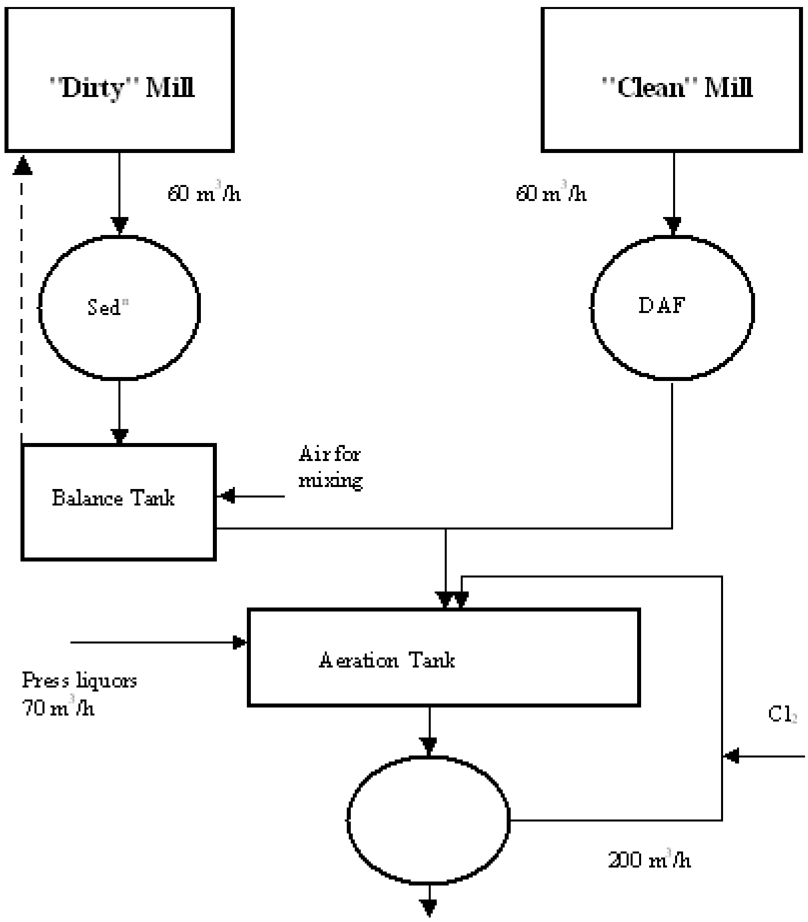

Figure 1: Schematic of the Flint wastewater treatment plant

The performance of the activated sludge process is limited by the ability of the settlement tank to separate and concentrate the sludge from the treated effluent. This limitation stems from physical properties of the activated sludge floc which affect its settleability and compactability. The physical characteristics of bulking are slow sedimentation rate, high settled sludge volume index (SSVI ^{3}120) and the excessive growth of filamentous micro-organisms within or external to the sludge floc structure. Activated sludge bulking can cause high settlement tank blanket levels, risking loss of solids in the final effluent. This results in a thin sludge with a low mixed liquor solids concentration, in the aeration tank, and affects also the recycling rate of the sludge.

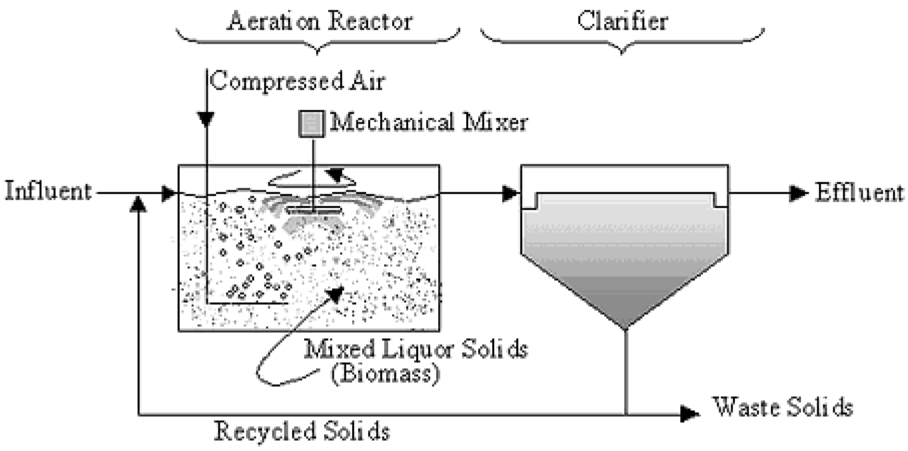

Figure 2: A schematic diagram of the activated sludge process

The formation of stable surface foams, which is associated with characteristic filamentous micro-organisms, is also a well documented phenomenon on activated sludge plants. In excess, it can create operating difficulties and may cause a violation of effluent consent conditions due to high concentrations of suspended solids and solid-related biochemical oxygen demand. Despite its occurrence, the reasons for foaming are not clearly understood, and control measures tend to be non-specific, hit-or-miss strategies.

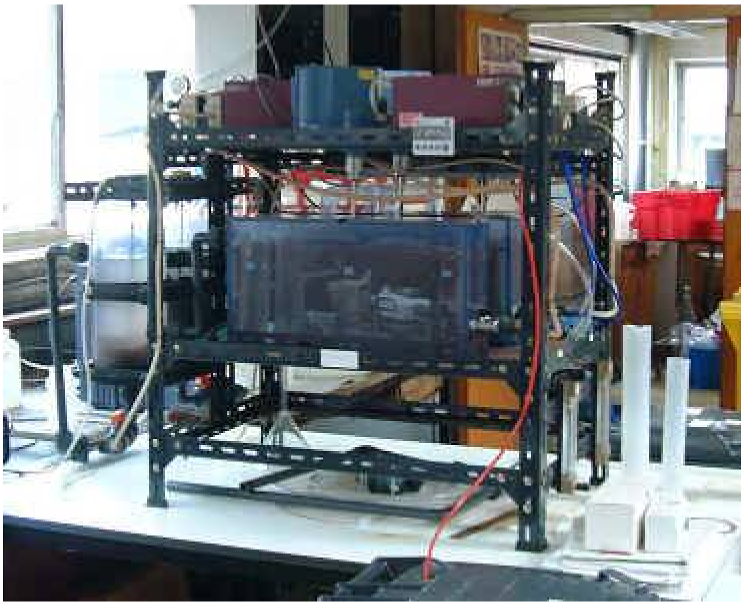

Plate 1: Experimental-laboratory equipment

Results

- COD removal is affected from low dissolved oxygen and high organic load.
- Low dissolved oxygen caused loss of protozoan activity and inhibit the floc growth.
- High levels of ammonia in the effluent corresponded when dissolved oxygen was limited in the aeration tanks and because of solids loss, when foaming occurred.
- Non-filamentous bulking has occurred because of the presence of zoogloean organisms in the cardboard wastewater.
- The methods employed to control bulking were the addition of calcium nitrate in the feed and the increase of the returned activated sludge (RAS).
- The formation of stable foams was associated with the dominance of the Nocardia species, Type 0092 and S. natans.

- The methods tested to control foaming were initially the addition of calcium nitrate, fine powder, both unsuccessfully and then mechanical foam removal.
- The correlation between settlement and filament abundance was not possible.
- Low dissolved oxygen and organic overload supported the growth of NALO.