ZELFLOCC WASTEWATER TREATMENT TECHNOLOGY

1. INTRODUCTION

ZELflocc is a process for the enhancement of wastewater purification systems which utilises the unusual properties of the natural mineral zeolite to improve the performance and/or capacity of existing treatment systems, or to reduce capital expenditure on new treatment systems.

Usually applied to activated sludge systems, the ZELflocc process utilises specially prepared zeolitic material to attract dispersed particulate matter and heavy metals, significantly improve sludge settleability, minimise sludge odour, and reduce both polymer requirements for dewatering and metal salt requirements for phosphorus precipitation. Dried sludges also have an open structure which is particularly suited to composting and vermiculture (composting with worms).

2. THE ZELflocc PROCESS

2.1 GENERAL

In the ZELflocc process specially prepared zeolitic material is added to wastewater during, or just prior to treatment. This ZELflocc powder attracts dispersed particulate material, forms a core on which organisms can grow, and assists in the generation of sludges with good settling and dewatering characteristics.

Odours are very rapidly taken up by ZELflocc, heavy metals are removed even when at low concentration in solution, and metal salt requirements for phosphorus precipitation are reduced. When applied during plant start-up foaming is minimal, and effective removal of suspended solids and oxygen demand occurs even before true biological flocs have had time to form.

Some benefits of ZELflocc can be observed immediately after dosing commences, indicating physico-chemical mechanisms, but major improvements in settleability frequently take some weeks to become apparent, as the process induces biological changes in the system.

Proper sizing of the ZELflocc powder is very important to the proper operation of the process. The powder is intimately mixed into the biomass of the treatment system upstream of the reactor, within the reactor, or in the sludge return stream. It may be added in a dry form or as a slurry, and while steady dosing is preferred this is not critical for most applications.

The ZELflocc powder is not separated from the sludge prior to wasting, and continues to provide beneficial effects, such as odour control, easier dewatering, and suitability for composting and vermiculture, during subsequent sludge treatment and reuse.

2.2 SETTLEABILITY IMPROVEMENTS UNDER ZELflocc

Many causes have been proposed for poor settleability of activated sludges, but at this time none of the theories are very satisfactory. Excessive filament growth has frequently been associated with poor settleability, but this is not always the case, and even when it is the variety of organisms identified, and the wide range of associated plant operating conditions, suggests that there may be several different causes.

Under ZELflocc bacteria grow on the surface of the zeolitic material and compete with other bacteria (such as filaments) for the available food. The resultant sludge mass settles well, leaving a very clear liquid due to attraction of fine dispersed matter onto the zeolitie material. A reduction in filament numbers has often been associated with settleability improvements produced by ZELflocc, but even when settling well it is not unusual for a large number of filaments to be associated with the flocs, although they no longer seem to extend excessively beyond the boundaries of the flocs.

Among the advantages arising from improved settleability, depending on the way this is applied, are greater plant capacity and increased sludge age for the same load (thus enabling, for instance, nitrification in a plant not currently achieving this). ZELflocc has been used to achieve both of these or, in other instances, to improve the efficiency of subsequent sludge handling facilities.

2.3 OTHER IMPROVEMENTS DUE TO ZELflocc

Under ZELflocc heavy metals are very effectively removed from solution, even when present in solution only at very low concentrations. These metals are then bound so strongly that they are unavailable to plants grown in soils to which the sludges have been added.

Phosphate, being anionic, is not attracted to the zeolite framework, but much of the earlier process development carried out involved the addition of natural zeolites in conjunction with aluminium and iron salts being used for phosphorus precipitation It was found that equivalent phosphorus removals could be achieved at about half the normal metal salt dosage, and that performance of the systems was less affected by interruptions to metal salt dosing. Work to date has confirmed equivalent performance at a twenty to thirty percent alum reduction, and further work in this area is proposed.

Odour is very rapidly removed under ZELflocc. Ammonium ions are known to be very effectively removed from solution by exchange onto clinoptilolite, but such a mechanism would not be effective for anions such as sulphide, so it appears likely that adsorption is also a significant mechanism. Removal appears particularly effective with odours arising from sludge processing, but significant reductions have also been observed where sulphide would be expected to be significant, such as in one reactor where partial aeration failure resulted in the contents having a very septic appearance, but little odour.

Sludges from processes operated under ZELflocc dewater readily, and have an open structure suited to composting and vermiculture. In one sludge thickening application a polymer reduction of twenty five percent was noted after ZELflocc dosing was introduced to the oxidation ditch generating the sludge. Odour removal benefits obtained from ZELflocc dosing of activated sludge extend through subsequent sludge handling and reuse stages, and are particularly apparent where sludges may have to be stored or reused without adequate stabilisation.

3. AUSTRALIAN EXPERIENCE

A major difference between earlier processes and ZELflocc is that earlier processes limited nitrification in activated sludge in order to conserve nutrients and energy, with excess ammonia being removed in a subsequent ion exchange filter. ZELflocc, on the other hand, has so far concentrated on improving the performance and capacity of existing plants with minimal capital expenditure, and hence improved nitrification and denitrification within activated sludge has been actively promoted.

ZELflocc has been applied in Australia to a wide range of conditions, with plants varying in flow from 40 kL/d to over 50 ML/d, sludge ages from around 1.5 days to in excess of 40 days, and along the east coast of Australia from near Townsville in the north to Melbourne in the south. Plant configurations have included oxidation ditches, both continuous flow and intermittent decant, conventional cellular configurations, and package plants. The process has been applied with both diffused air and mechanical surface aeration (both vertical axis and brush types). Sludge treatment systems have included aerobic and anaerobic digestion, lagooning, drying beds, sludge thickening, and sludge dewatering.

4. INTELLECTUAL PROPERTY

ZELflocc technology is a process that provides a significant enhancement of the activated sludge sewage treatment process.

ZEL has filed for patent protection on this technology following many years of research and support by way of grants from Federal and State Governments in Australia.

One of the key outcomes of the ZELflocc technology is an increase in the biological activity of the treatment process. The ZELflocc particles suspended in the activated sludge tank provide a medium in which bacteria can colonise and grow. They can attract the waste through chemical, electrical and physical means, and form more compact groupings (‘floccs’) than conventional activated sludge, thereby allowing more efficient oxygenation.

It follows that the intensive capital expenditure needed to increase the processing capacity of existing processing facilities (ie. building more tanks and associated equipment) can be minimised/deferred.

Thus the ZELflocc process can achieve the desired outcomes with minimal capital outlay (particularly relevant in an environment where the Governments all over the world are facing tight budgetary situations).

4.1 PERFORMANCE DATA

4.1.1 SLACKS CREEK STP – LOGAN CITY COUNCIL

The ZELflocc process was demonstrated on a trial basis at Slacks Creek STP during 1995 – 1996. This trial demonstrated the efficacy of the ZELflocc process in improving the performance of activated sludge treatment systems under Australian conditions and the targets set down as a Milestone were achieved. Industry Research and Development Board (IRDB) Project Final Report #GRA00128 comments: -

*The sludge volume index (SVI) of the mixed liquor has been reduced from around 150mL/gm to better than 75mL/gm, i.e. an improvement of over 50%. The SVI achieved was, generally better than 50mL/gm, with recent excursions up to 75mL/gm being associated with scraper problems in the primary sedimentation tanks. These figures compare very favourable with both the normal design figure of 150mL/gm and the generally recognised level for good settleability of 100mL/gm.

Effluent ammonia levels were reduced from typical values of the order of 10-30mg/L to levels which were consistently under 5mg/L, and frequently under 2mg/L, representing an improvement of at least 50%, and more generally 80-90%.

While not quantified, it has also been observed that since the ZELflocc process commenced the liquor returned from the aerobic digester is no longer septic, indicating that there is now sufficient aeration in that unit, eliminating odours in the immediate vicinity of the plant, and reducing the loading to the activated sludge plant itself.

*Source: Industry Research and Development Board/Project Final Report/Project Number GRA00233/Period of Report 1-8-96 to 30-6-97

These results are very significant as they indicate ZELflocc has at least doubled the capacity of the existing treatment works, while at the same time providing improved effluent quality. Further evidence of this substantial increase in capacity is provided by the fact that Logan City Council chose to close down half the aeration tank capacity in the latter stages of the trial yet the ZELflocc process was able to maintain satisfactory treatment of the full amount of incoming sewage.

4.2 CASE STUDIES

ZEL embarked upon an extensive program during 1996-1997, which further verified the ZELflocc process at other STPs. A selection of these STPs together with the resultant findings are summarised in the extract below:
Source –(IRDB) Project Final Report # GRA 002333: -

Slacks Creek (Logan City Council) Settleability Enhancement Maintained

This plant had commenced operation under "ZELflocc" as part of the Stage 1 trial, and was incorporated into the Stage 2 trials to demonstrate the long-term effectiveness of the "ZELflocc" technology. The improved settleability from Stage 1 was maintained, at SVI levels less than 50 ml/g, compared to levels above 200 ml/g prior to "ZELflocc". The improvement in settleability was maintained, except when dosing was suspended due to dosing machine problems. Settleability improvements recovered rapidly after dosing recommenced.

In March dosing was deliberately suspended to confirm that the enhanced settleability observed was definitely due to the dosing regime Settleability deteriorated to levels found prior to the trial, indicating the improved settleability was a result of the "ZELflocc" addition. Trials were completed on time and all technical milestones were met.

Bundaberg East (Bundaberg City Council) 50%Improvement in Settleability

Settleability improved slower than expected at this plant. The overall settleability target of 50% was achieved by the end of the trial, from levels of 350-400 ml/g to less than 200 ml/g. In addition substantial secondary benefits were achieved, including reduced polymer requirements for sludge thickening, and a noticeable reduction in odour problems from drying sludge.

Vincentia (Shoalhaven City Council) 20% Reduction in Alum Dosing

The primary focus of this trial was to determine the degree to which "ZELflocc" could substitute fro alum dosing and maintain effective phosphorus removal. Trials were delayed due to delays in installing specialised dosing equipment, however once installed two 10% alum reductions were completed and phosphorus levels in treated effluent were maintained at existing levels. A third 10% reduction in alum dosing was initiated, however, change in plant operating procedures nullified the results from this testing regime.Trials were not completed on time due to dosing equipment delays, however, technical milestones were achieved.

Bonny Hills (Hastings Council) 65% Improvement in Settleability

Settleability at Bonny Hills varies seasonally in response to changes in loading resulting in the failure to meet the first milestone, Subsequent milestones were all satisfied and ultimately exceeded. The trial involved "ZELflocc" addition to one channel and no addition to a parallel control channel. Settleability results improved from 100-250 ml/g prior to the trial to levels between 50-100 ml/g. It was found that the ZELflocc channel outperformed the control channel and that stress
deterioration in the "ZELflocc" channel was less pronounced and recovered more quickly than the control channel. Trials were completed on time and technical milestones achieved and exceeded.

Bolwarra (Hunter Water) 75% Improvement in Settleability

All milestones were met and ultimately exceeded. Settleability under "ZELflocc" has been reduced by 60-75%. SVI levels of 60-100 ml/g have been achieved, from pre-trial levels of 300-400 ml/g. Significant secondary benefits were achieved in the form of deferred lagoon desludging caused by a lower volume of waste sludge. This has deferred desludging by at least nine months, resulting in significant savings for the plant operator.

Trials have been completed on time and all technical milestones met.

Medowie (Hunter Water) 80% Improvement in Settleability

This site suffers from extreme overloading and, in part was selected for this reason. The settleability achieved for each milestone was met and exceeded. Settleability has improved from pre-trial SVI of 300-500 ml/g to levels between 60-150 ml/g, a 80% improvement. Additional operating benefits were achieved under "ZELflocc". Plant cycle time was reduced by two hours, effectively doubling plant capacity. Mechanical failure of aerators prior to "ZELflocc" resulted in septicity, with low dissolved oxygen and poor mixed liquor colour, but did not cause similar problems under "ZELflocc". The company views this plant as a major success of the program. Trials were completed on time and all milestones exceeded.

4.2.1 BRISBANE WATER

Oxley Creek WWTW (Brisbane Water)

This conventional activated sludge plant, of about 220,000 E.P (55 MLPD), was designed for carbonaceous BOD removal, but not for nitrification. Under partial funding from the Queensland Government's AWTT scheme it has recently been demonstrated on about half of this plant that full nitrification can be obtained in winter without modification of the civil structure. This has important implications for nutrient removal in STPs particularly as a variety of strategies can be implemented to achieve a significant degree of denitrification, dependent on existing plant constraints. (This work is reported in a paper by Barr, Balthes & Cooksey, which can be found in the Proceedings of the AWWA Federal Convention, 1999)

A study carried out by Brisbane Water on the economics of using the ZELflocc process has proven that this innovative technology delivers major cost benefits.

The study showed that using ZELflocc in a 200,000 equivalent population plant can achieve substantial capital cost savings. In this particular case, the capital cost saving is in the order of **$20-25 million** compared with a conventional upgrade to achieve the same level of nitrogen removal.

Based on these scientific and economic conclusions the wastewater industry will derive major benefits from the installation of the ZELflocc process.

4.2.1.2 Fairfield WWTW (Brisbane Water)

Fairfield WWTW is a high rate activated sludge plant which, prior to implementation, was operated at a sludge age of about 2.5 days due to difficulties with sludge settleability. With implementation of ZELflocc, improved settleability enabled sludge age to be increased to about 7.5 days, with further increase being difficult due to the method of control of sludge wasting.

As these works are not designed for scum removal and there was some concern about possible solids entrainment in the effluent from mild scums generated at this higher sludge age, ZELflocc dosing was suspended for a short time. ZELflocc was re-instituted due to the obvious adverse effects on anaerobic digestion when sludge age had to be reduced as settleability deteriorated without ZELflocc.

4.2.1.3 Gibson Island (Brisbane Water)

Gibson Island treats an equivalent population of over 140,000 and is a large extended aeration plant with sludge wasted to a picket fence thickener and then directly to dewatering.

A key issue at Gibson Island is that the sludge settleability has not been as good as in some of the other plants operated by Brisbane Water. This becomes particularly significant in wet weather (storm) events where a portion of influent may have to bypass the main treatment works in order to enable the treatment integrity to be maintained for the bulk of the flow.

The ZELflocc process operated for a continuous 18 month demonstration period and showed that the plant capacity could be significantly increased to meet a target 3 times dry weather flow criteria. The plant operators also experienced that under ZELflocc the clarifier recovers more rapidly from storm flows,meaning the plant reverts to normal operation much sooner.

5. SUMMARY

It can be seen from the above that ZELflocc offers exciting possibilities for improvements to, and cost savings for, municipal wastewater treatment systems. It should be emphasised, however, that these advantages are not limited to municipal systems, being equally applicable to many industrial situations.

From an environmental point of view ZELflocc offers a low cost, easy to implement, means of providing enhanced environmental protection, greater system capacity, reduced odour both during treatment and subsequent sludge reuse, receiving water protection from heavy metals, reduced metal salt additions for phosphorus precipitation, and desirable characteristics for sludge reuse.

ZELflocc benefits include:

- Increased plant capacity reduces capital expenditure and running costs.
- Improved effluent quality (reduced nutrients) assists authority compliance and provides greater protection to the receiving environment.
- Diminished chemical costs due to reduced dosing for nutrient removal.
- Improved sludge characteristics improve resale value of sludge.
- Improve dewaterability of sludges can result in disposal cost savings.
- Reduced polymer requirements for sludge de-watering reduces chemical costs.
- Reduced levels of odour assist EPA compliance and public complaints.