NOVEL APPLICATION OF A LAMELLA CLARIFIER FOR IMPROVED PRIMARY TREATMENT OF DOMESTIC WASTEWATER

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ABSTRACT

The effectiveness of a lamella clarifier unit for primary treatment of domestic wastewater was investigated. The trial was divided in to three operational phases: Phase I – operation of a conventional primary sedimentation tank; Phase II: operation of a lamella clarifier for primary settlement; Phase III – operation of lamella clarifier for primary settlement in conjunction with a chemical coagulant (aluminium chlorohydrate). The performance of the lamella clarifier was assessed in terms of the biochemical oxygen demand (BOD_5), suspended solids (SS), total nitrogen and total phosphorus removal efficiencies. Results demonstrated that the lamella clarifier unit performed favourably when compared to the conventional primary sedimentation tank, with BOD_5 and SS removal efficiencies of 30% and 57%, respectively (Phase II). The operation of the lamella clarifier in conjunction with coagulant (Phase III) enhanced nutrient removal, thereby improving the overall performance of the system.

Keywords:

Lamella clarifier; nutrient reduction; primary sedimentation; process efficiency; solids removal.

1.0 INTRODUCTION

Lamella clarifiers are designed to remove particulate matter from liquids. These systems have been used extensively for industrial, construction and environmental remediation applications. In contrast to conventional sedimentation/clarifying units, lamella clarifiers contain a series of inclined plates, which provide a large effective settling area within a considerably smaller footprint. The influent solid/liquid stream is stilled upon entry into the lamella clarifier unit, and solid particles settle onto the plates, accumulating and thickening in collection hoppers at the bottom of the unit; the clarified liquid exits the system through an outlet weir (Fig. 1).

The apparent advantages of these systems over conventional primary settlement tanks led East Gippsland Water to investigate their effectiveness for primary treatment of domestic wastewater.

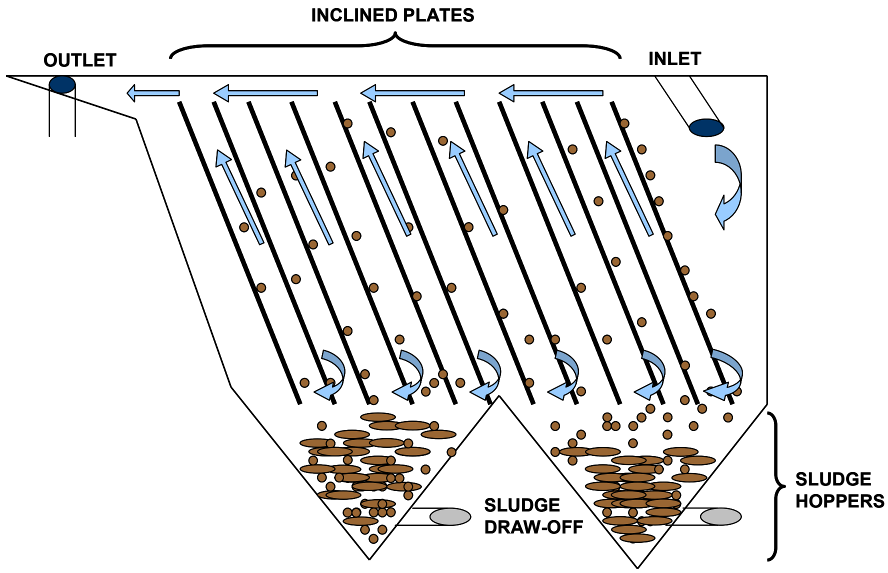

Figure 1: ***Schematic of the lamella clarification process.***

1.1 Site Description

A full-scale trial was commissioned in March 2010 at Dinner Plain wastewater treatment facility in Victoria. The facility is located in the Alpine region and, due to its popularity as a winter tourist destination, is subject to large seasonal fluxes in the quality and quantity of the influent wastewater. During normal operation, the treatment facility consists of preliminary treatment via a mechanical step-screen, followed by primary sedimentation in a conventional sedimentation tank (Fig. 2a). Primary effluent is discharged to a series of oxidation/polishing lagoons. All reclaimed water is beneficially reused for irrigation purposes. Primary sludge is digested in an aerobic digestion tank (Fig. 2a).

1.2 Description of the Lamella Clarifier Unit

A 'SiltBuster® HB50' lamella clarifier unit was acquired, the details of which are described in Table 1.

Table 1: ***Technical and operational information relating to the lamella clarifier.***

Plate Spacing Configuration (mm)[a]	Effective Plate Area (m^2)	Hydraulic Capacity (L/sec)[b]	Typical Operating Range (L/sec)	Sludge Capacity (m^3)
25	50	20	0.2 to 14	2.2
50	25	10	0.1 to 7	2.2

[a] *To avoid inter-plate clogging when treating unsettled wastewater, every second inclined plate was removed to allow 50 mm spacing between plates;*
[b] *Total hydraulic capacity approx. 7.5 m^3.*

Initially, sludge was drawn from the sludge hoppers twice a day, for a 30-second period. The primary sludge was pumped to a geotextile bag, housed in a bunded container, with the liquid drainage from the bag discharged to the oxidation lagoons.

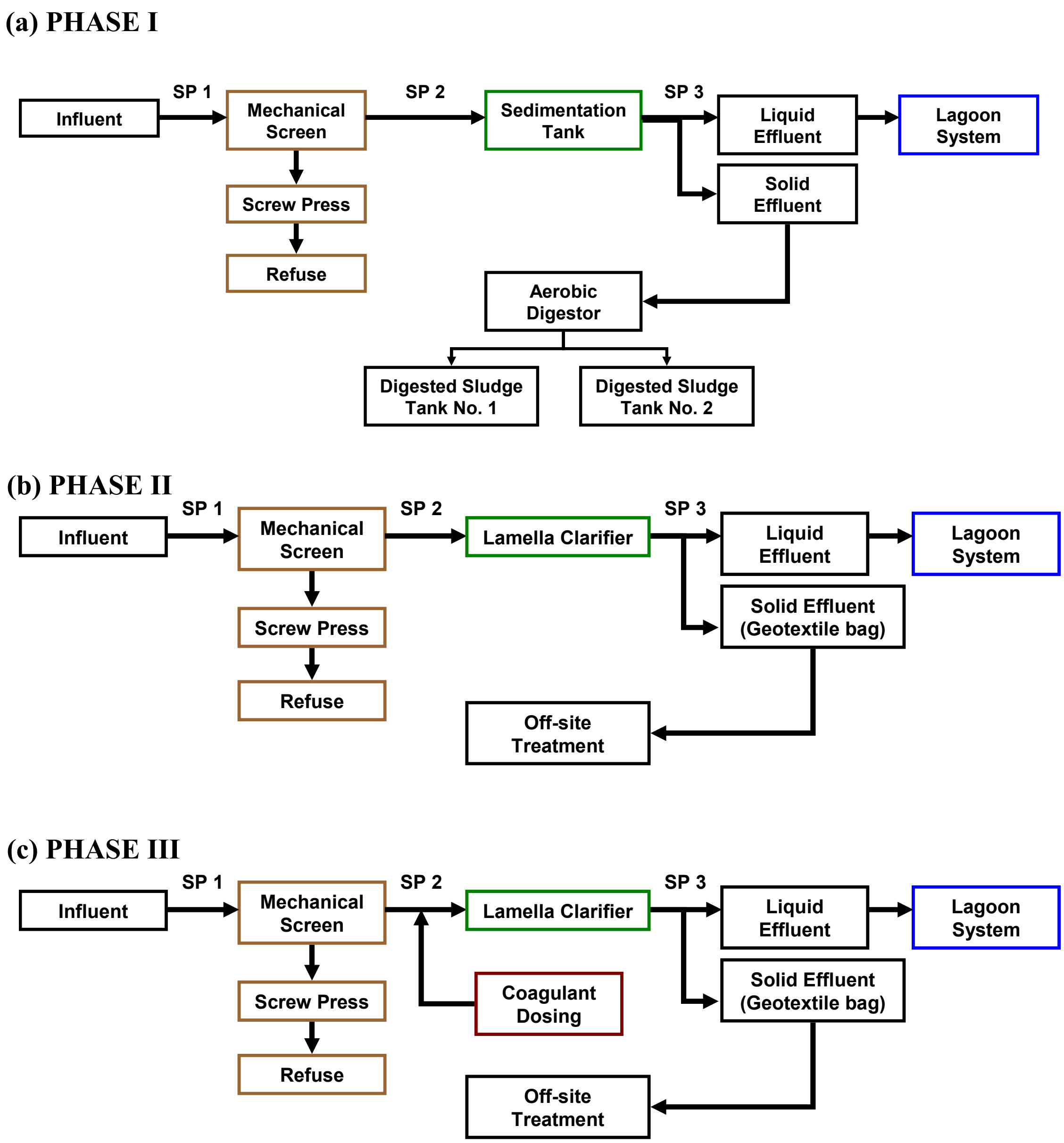

Figure 2: ***Schematic of the treatment process at Dinner Plain wastewater treatment facility during (a) Phase I [primary sedimentation tank online] (b) Phase II [lamella clarifier unit online] and (c) Phase III [lamella clarifier operating in conjunction with coagulant dosing]; SP1 to SP3 denotes designated sample points.***

1.3 Description of the Trial

In order to evaluate the performance of the lamella clarifier unit relative to the existing primary sedimentation tank, testing was performed before and after the lamella clarifier was brought online. The concentrations of biochemical oxygen demand (BOD_5), suspended solids (SS), total nitrogen (TN) and total phosphorus (TP) were determined for each sample.

The trial was divided into three experimental phases:

Phase I: operation of the primary sedimentation tank (Fig. 2a);
Phase II: operation of the lamella clarifier (Fig. 2b);
Phase III: operation of the lamella clarifier with coagulant dosing of the preliminary effluent (Fig. 2c).

Poly aluminium chlorohydrate (PAC 23) was used as the coagulant at a dose concentration of 30 ppm. The dosing station was located between the step screen and the lamella clarifier unit (Fig. 2c), where the preliminary effluent was pumped from a holding pit to the lamella clarifier at a rate of approx. 2.5 L/sec.

Testing was performed on samples from the influent (raw) wastewater (SP1), preliminary treatment effluent (SP2) and effluent from either the primary sedimentation tank or the lamella clarifier unit (SP3; Fig. 2). Samples were composites of at least 5 grab samples, blended over the course of the day, to represent both peak and off-peak daily flows.

2.0 RESULTS AND DISCUSSION

In general, the BOD_5 and SS concentrations were found to be higher in the preliminary effluent (SP2) than in the raw influent (SP1). This observation is likely due to solid material breaking up during the preliminary treatment process. As such, removal efficiencies for each parameter were calculated as the percentage reduction in value recorded between SP2 and SP3.

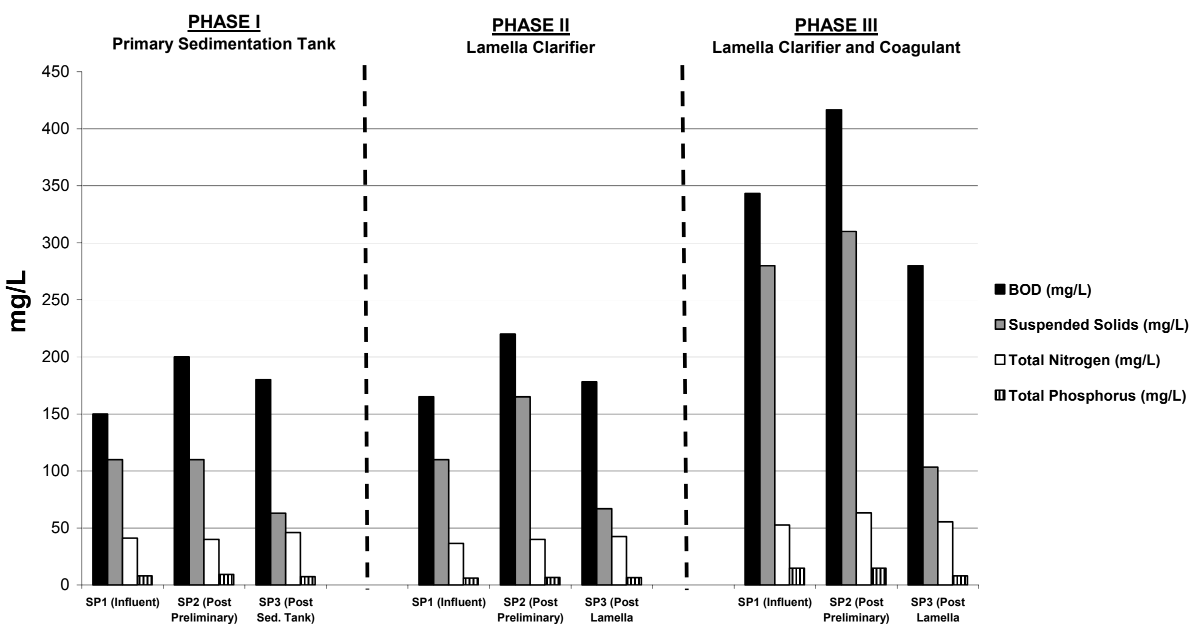

Figure 3. ***Evaluation of the performance of the primary sedimentation tank (Phase I; values represent samples taken on 2nd March, 2010), lamella clarifier (Phase II; values represent the average of composite samples taken on 9th and 17th March, 2010) and lamella clarifier and coagulant (Phase III; values are the average of samples taken on 31st March, and***

6th and 26th May, 2010).

During Phase I (Fig. 2a), the primary sedimentation tank reduced the SS concentration of the preliminary effluent by 43% (Fig. 3 and Table 2). BOD_5 and TP levels were reduced by 10% and 21%, respectively, whilst no reduction in TN was observed (Figure 3 and Table 2).

Once the primary sedimentation tank was taken offline, and the lamella clarifier unit was in operation (Phase II; Fig. 2c), the overall performance of the lamella clarifier compared favourably to the primary sedimentation tank (Phase I), with SS removal efficiencies increasing to 57%; a corresponding increase in BOD_5 removal was observed (30%; Fig. 3 and Table 2). In contrast, nutrient levels remained relatively unchanged, with observed TN and TP removal efficiencies of 1% and 6%, respectively (Fig. 3 and Table 2).

Table 2: ***Removal efficiencies during the trial period*** [a]**.**

Trial Period	BOD_5 Removal (%)	SS Removal (%)	TN Removal (%)	TP Removal (%)
Phase I (Primary Sedimentation Tank)	10	43	<1	21
Phase II (Lamella Clarifier)	30	57	1	6
Phase III (Lamella Clarifier/Coagulant)	31	59	15	47

[a] *Removal efficiencies were calculated as percentage reduction in values recorded between SP2 and SP3.*

In an attempt to further improve the performance of the lamella clarifier, coagulant dosing commenced in Phase III (Fig. 2c). During this phase, higher organic loads were observed relative to Phases I and II, which may be as a result of (i) increased occupancy within the town due to the start of winter season and/or (ii) reduced infiltration arising from an extensive sewer repair programme undertaken during this period.

Despite the higher organic loading during Phase III, BOD_5 and SS removal efficiencies were similar to those obtained during Phase II (Fig. 3 and Table 2). Higher nutrient removal was observed during Phase III, with TN and TP removal efficiencies of 15% and 47%, respectively (Fig. 3 and Table 2). The higher TP removal is likely due to the formation of chemical phosphorus precipitates, arising from the addition of coagulant, with subsequent settling out on the inclined plates of the lamella clarifier unit. The reason for improved TN removal during Phase III is unclear, and needs further investigation. In addition, settleable solids were measured during Phase III using a series of 1L Imhoff cones; >90% removal of settleable solids was observed during this period (Table 3).

Table 3: ***Removal of settleable solids during Phase III.***

Sample Point	Settleable Solids Concentration (mg/L)[a]
SP1 (Raw Influent)	**12**
SP2 (Post Preliminary Treatment)	**17**
SP3 (Post Lamella Clarifier)	**1**

[a] *Values are averages from composite samples performed on 31st March, 6th and 26th May,*

2010.

Based on the results from this evaluation, the performance of the lamella clarifier, operating in conjunction with coagulant dosing, compares favourably to the primary sedimentation tank, improving the overall effectiveness of primary treatment at the Dinner Plain treatment facility. This in turn will reduce the organic loading to the lagoon system. Importantly, the improved nutrient quality should reduce the likelihood of algal blooms occurring during the summer months, thereby minimising potential disruption to irrigation.

Future consideration will be given to evaluating the efficacy of the primary sedimentation tank operated in conjunction with coagulant dosing, as this configuration may produce comparable results to those observed during Phase III.

It is likely that optimisation of the coagulant dosing regime will further improve the overall efficiency of the lamella clarifying unit; jar testing studies are currently underway to investigate the influence of reduced wastewater temperature on the rate of floc formation, and the feasibility of commissioning a flocculation tank prior to the lamella clarifier unit is being evaluated.

Importantly, these encouraging results reflect operation during the relatively quiet, off-peak spring period (flow rate, 1-4 L/sec). At the time of publication, the trial was entering the busy winter period (flow rate, 5-10 L/sec). The process performance and sludge draw-off will now need to be closely monitored and optimised for the peak winter hydraulic/organic loads.

3.0 CONCLUSIONS

In summary, the lamella clarifier operated in conjunction with coagulant dosing has improved the overall quality of the primary effluent at Dinner Plain wastewater treatment facility.

The ability of this system to cope with peak winter flows will now be evaluated. In addition, optimisation of the coagulant dosing regime will be investigated, in an attempt to further improve system performance.

4.0 ACKNOWLEDGEMENTS

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