REFEREED PAPER

STEPS TAKEN TO REHABILITATE THE EFFLUENT TREATMENT PLANT AT PONGOLA SUGAR MILL

NDLAZI M, SINGH RI AND NDLOVU S

TSB Sugar, PO Box 23, Pongola, 3170, South Africa
ndlazim@tsb.co.za singhr@tsb.co.za ndlovus@tsb.co.za

Abstract

This paper deals with the remedial measures taken at the Pongola sugar mill to restore the performance of the Effluent Treatment Plant (ETP) with the objective of improving the quality of the final treated effluent. The Pongola ETP has been generously sized; however, over the years this capacity has been eroded due to high suspended solids ingress combined with elevated hydraulic loading. Incidents of water quality noncompliance with local regulations necessitated interventions to improve the quality of treated effluent. A programme of investigation to determine reasons for drop-off in performance followed by phased action plans to rehabilitate the Pongola ETP are detailed in the paper.

Keywords: sugar mill, effluent treatment, waste water quality, COD, environment and final effluent

Introduction

The Pongola sugar mill is a sugarcane factory with a back-end refinery, processing ±6000 TCD and producing ±700 tons of sugar per day.

After inception, the quality of treated effluent from the ETP facility at Pongola has met the local regulations and standards for waste water. However, over the years, slippage in maintenance standards combined with a drop in operational focus, on monitoring and control measures on both the ETP and effluent leaving the factory, the performance of the treatment facility deteriorated. Increased hydraulic loading after factory expansion has aggravated the decline.

This situation has resulted in poor performance of the effluent treatment system and deterioration of the quality of the final discharged effluent. The quality of the treated waste water could not consistently meet the required standards. This has dictated an urgent need to correct the situation or face penalties from the local regulating authorities.

Sugar mill effluent treatment

The sugarcane entering the factory has approximately 70% moisture. During processing, most of this moisture is condensed in heat exchangers and the remaining portion is condensed in cooling water in direct contact condensers. Condensates are reused during processing and cooling water is recirculated; however, during steady running conditions excess condensate and excess cooling water overflows as waste water. Evaporator flushing and factory washings result in peak flows during shutdowns. Potable and/or raw water used for cooling duty or as make-up, aggravates the volume of waste water produced. Waste water leaving the factory may contain traces of sugar, cane fibre and suspended matter. Oil and lubricants leaking from factory machinery may further contaminate factory waste water. Due to stringent regulations on waste water discharge, this stream has to be treated before it can be discharged into the receiving environment. Considerable research work has been conducted in the South African sugar industry on the treatment of waste water originating from a sugar mill using anaerobic and aerobic treatment (Purchase and Perrow, 1983). This research has resulted in the successful application of this technology for the treatment of sugar mill waste water.

Typically the quantity of the waste water from a sugarcane factory is approximately 20-25% of the cane processed. This waste stream, which is organic in nature, consists largely of varying concentrations of sugar traces. Traces of inorganic material, mainly calcium derived from milk of lime spillages and that used for injection water pH control as well as sand and ash from the caneyard and from thee boiler plant is also present.

Since the waste water originating from a sugar mill comprises mainly organic compounds, controlled biological treatment processes can be applied. Biological treatment may be either anaerobic or aerobic, or usually in combination, depending on the type of bacteria used and the condition faced.

Anaerobic systems are ideal for treating highly concentrated wastes but are not suitable for producing a high quality effluent. The anaerobic pathway comprises acid fermentation, during which organic acids break down into acetic acid, carbon dioxide and hydrogen. Also occurring is methane fermentation, where methanogenic bacteria convert acetic acid into methane gas, hydrogen and carbon dioxide. If there is not enough methanogenic activity to degrade the acids produced, these accumulate, thereby dropping the pH and producing odours. Nitrogen and phosphorus are essential nutrients for growth of microorganisms present in the system and are added from time to time.

The aerobic process utilises bacteria that require oxygen to breakdown sucrose into carbon dioxide and water. Generally, oxygen requirements are roughly 1 kg O_2/kg biological oxygen demand (BOD). (personal communication[1]). In sugar factory effluent the main component which has to be oxidised is sucrose:

$$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$$

Routine tests are undertaken to monitor and control plant performance. These are: chemical oxygen demand (COD), pH, suspended solids, mixed liquor suspended solids (MLSS) and sludge volume index. COD is a measure of the amount of oxygen needed to oxidise all of the effluent into carbon dioxide and water.

Supplementary nutrients such as nitrogen and phosphorus are added from time to time to ensure proper growth of micro-organisms present in the system. The amount of nutrients required should be sufficient to ensure that the COD:N:P ratio of the mixed liquor of the anaerobic stage is 100:1:0.2 and the aerobic stage is 100:2:0.4 (Bruijn, 1975).

[1] Dr BS Purchase

Description of the Pongola mill plant

The Pongola sugar mill ETP comprises a combination of anaerobic digestion followed by aerobic digestion and a final polishing dam operating in sequence. The layout of the Pongola mill ETP, which is close to the Pongola River, is depicted in Figure 1. The treatment system was also designed with a surge dam to accommodate influent flow surges.

- Dam 1: A pre-settling dam with a capacity of 5,200 m^3, it is a simple open lagoon type dam using gravity sedimentation to remove suspended solids. This dam also serves as an anaerobic dam. The designed retention period is three days. Sedimentation is a necessary treatment step to decrease suspended solids which would otherwise increase turbidity if discharged into a natural waterway inhibiting light transmission with resultant death of photosynthetic organisms.
- Dam 2: An anaerobic pond with a capacity of 11 288 m^3, it is an open lagoon type anaerobic dam. The designed retention period is 7.5 days.
- Dam 3: An aerobic pond with a capacity of 12 606 m^3, it is equipped with three floating, slow speed surface aerators driven by 22 kW motors. The designed retention period is 8.4 days.
- Dam 4: A Pasveer ditch of 1 800 m^3, it is equipped with three 30 kW disk aerators. The designed retention period 1.2 days.
- Dam 5: A maturation dam of 42 709 m^3 capacity for polishing effluent before discharge into the river. The designed retention period is 28 days.
- Surge dam: An anaerobic dam with a capacity 8 000 m^3 to accommodate surges thereby preventing sudden high hydraulic loading into the treatment plant. The designed retention period is 5.3 days.

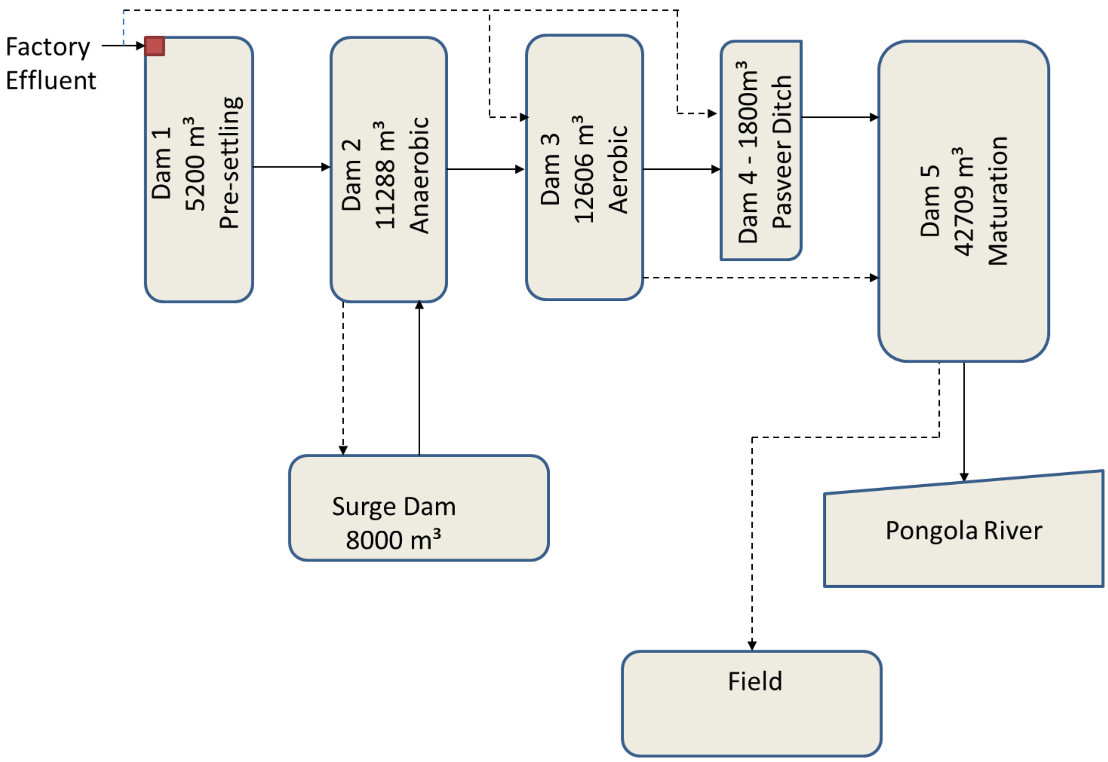


Figure 1: Layout of Pongola mill effluent treatment plant.

The total storage capacity of Pongola mill effluent treatment is 73 603 m^3 with storage capacity of approximately six weeks.

The generous volumetric capacity and proven treatment regime of pre-settling, anaerobic treatment followed by aerobic treatment and final polishing indicate that the Pongola ETP is adequately designed to treat normal sugar mill effluent and ensure that the final treated waste water meets the stringent regulation governing the disposal of treated waste water.

Current legislation and compliance

The use of water for industrial purposes and the control of effluent resulting from industrial processes are governed by the RSA Water Act of 1956, as amended from time to time. The Pongola sugar mill ETP has been registered with the Department of Water Affairs and Environment and a licence has been granted to dispose of *treated* waste water into the Pongola River. The quality of the treated waste water has to comply with the statutory general discharge limits as presented in Table 1.

Table 1. Waste water limits applicable to discharge of waste water into a water resource.

Substance/Parameter	Limit value
Chemical oxygen demand	<75 mg/L
Suspended solids	<25 mg/L
Free and saline ammonia (as N)	<10 mg/L
Dissolved oxygen	75% saturated
pH at 25°C	5.5-9.5
E. coli	0
Temperature	<35°C
Oil	<2.5 mg/L
Sodium	<90 mg/L above intake conc.
Lead	0.1 mg/L
Nitrate/nitrite as nitrogen	15 ppm
Orthophosphate	10 ppm

Other important requirements specified by legislation

- The registered user must follow acceptable construction, maintenance and operational practices to ensure effective plant operation with a consistent and fully compliant discharge.
- The registered user must ensure the establishment of monitoring programmes to measure the quantity and quality of the discharge prior to commencement of the discharge, as follows:
  - The quantity of the discharge must be metered and recorded on a daily basis.
  - The quality of waste water must be monitored and analysed prior to discharging into the water source.
  - The details of failures and malfunctions in the discharge system and details of measures taken must be made available upon request.
- Any information on the occurrence of any incident that has, or is likely to have, a detrimental impact on the water resource quality must be reported to the responsible Authority (Government Gazette No. 20256).

The above requirements as dictated by legislation are being more stringently applied. Therefore noncompliance greatly increases the legal risk to the company and could even lead to business closure.

Inspections and surveys at the Pongola ETP

A systematic approach was adopted by Pongola Mill Management to establish the reasons for the decline in performance of the ETP. Reviews of historical data and surveys conducted over of the past five years (2009 to 2013) have revealed the following:

- The capacity of the ETP had significantly reduced due to the accumulation of solids. The chemical analysis of sediment shown in Table 2 indicated very high ash content and a low percentage of volatile matter in the sludge.
- The dam survey to establish the extent of silting has indicated a loss in treatment capacity of 30-50%, as shown in Table 3.
- Influent flow rates were recorded during normal and peak periods. These indicated an average flow of 1955 m^3/day and a peak flow rate of 2880 m^3/day.
- The quality of the final effluent from the final pond has shown considerable deterioration over time in respect of the suspended solids, oxygen absorbed (OA) and chemical oxygen demand (COD) concentrations.
- The mixed liquor suspended solids (MLSS) concentration was found to be low, at between 1000 to 1200 mg/L, compared to the desired operational range of 3000 to 4000 mg/L. Furthermore, due to solids ingress, much of the MLSS was probably inert material, i.e. not live bacterial sludge.
- Frequent failures of the equipment and aerators were experienced.

Table 2. Chemical analysis of sludge (ERWAT laboratory services). Note that no analysis was done on Dam 4.

	Sludge sample			
Determinant (units)	Dam 1	Dam 2	Dam 3	Dam 5
% total solids	12.8	14.9	0.4	7
Ash % total solids	80.5	75.4	47.5	71.1
Volatile matter % total solids	19.5	24.6	52.5	28.9
Potassium (mg/kg K)	3295	3607	20472	4226
Total alkalinity (mg/L $CaCO_3$)	1384	892	563	2113

Table 3. Dam survey results (SAME Water (Pty) Ltd).

	Dam 1	**Dam 2**	**Dam 3**	**Dam 4**	**Dam 5**	**Total**
Water body volume (m^3)	5200	11288	12606	1800	42709	73603
Sediment volume (m^3)	2808	3838	2773	900	12813	23132
Average % volume reduction	54	34	22	50	30	31

The flow rate measurements and the surveys conducted clearly indicated an increase in influent flow rates and solids loading. The flow rate increases were greater than 30% and, at peak, almost double the design capacity. The ingress of solid ash was high and the tests also revealed carry-over of solids into all of the dams. The damaged disk aerators in Dam 4 as seen in Figure 7 had a detrimental effect on plant performance.

Figure 2. Dam 1 drying out for desludging.

Figure 3. Dam 1 silt accumulation.

Figure 4. Anaerobic pond, Dam 2, indicating poor anaerobic activity.

Figure 5. Dam 3 with two floating aerators instead of three aerators.

Figure 6. Ash-filled Pasveer ditch.

Figure 7. Dam 4 showing poor aeration with damaged aerator.

Project work and rehabilitation of the ETP

De-silting

The surveys conducted were useful in identifying problems and deciding the course of action to be taken. It was decided that the best approach would be a phased project programme to address rehabilitation of the dams. This solution was logical in that it was impractical to de-sludge whilst still maintaining operations. In addition, de-sludging is expensive and a phased operation allowed expenditure to be spread out. The de-silting of the dams required draining the liquid from the dams, drying out the solids under normal ambient conditions and removing the sediment utilising excavation machinery. The rehabilitation process commenced late in the 2009/10 milling season. One dam per year was de-silted to restore it to its original volumetric capacity. It is intended that the de-silting programme will now be an ongoing process.

Hydraulic and solids loading

An investigation was carried out to identify the sources of high hydraulic and solids loading. These are presented in Table 4, together with the remedial action taken. It is important to note that any water (raw and/or treated water) drawn into the plant from the main supply source (river water) ultimately leads to an increase in the flow to the ETP. Therefore one of the main objectives was (and still is) to reduce the overall water consumption of the factory and its surrounds.

Table 4. Findings and corrective action taken.

Findings	Corrective action and remedial work
Boiler Ash overflow Frequent overflows from the ash plant were observed due to excessive raw water make-up. Solids from this system were identified as the major source of solids ingress into the ETP.	The use of raw water was eliminated by substituting with condensate make-up which would have otherwise have ended up in the ETP. Overflows were tightly controlled, thereby reducing solid ingress into the ETP.
Rejection of condensate Frequent dumping of condensate due to high conductivity was traced to poor 1st and 2nd effect level control. In off-crop entrainment separators were found to be badly fouled. Pongola sugar mill does not have adequate buffer capacity for process condensate storage. This has resulted in excess condensate overflowing at mill stops and a shortage of condensate at start-up which requires large quantities of potable water to be introduced as makeup.	Attention was paid to level control set points and controller tuning. This resulted in considerably fewer occasions of condensate dumping. Cleaning and maintenance of entrainment separators is now part of the off-crop programme. A capital plan has been put in place to install a sufficiently large reject condensate tank. This will reduce potable water make-up and will eliminate the overflow of condensate into the ETP. This stream accounts for at least 30% of the hydraulic loading.
Plant Expansion 2005 A new scrubber plant to scrub flue gas for the refinery carbonatation process used raw water once through, which was then channelled into the ETP. The discharged water contained a large amount of solids originating from the boiler flue gas.	Scrubbing raw water was replaced with injection water which was then diverted to the boiler ash sluicing system. In 2010, CO_2 supply for carbonatation reverted to the lime kiln and the relatively clean scrubbing water is now diverted to the spray pond.
Raw water use Raw water was used as make-up water on vacuum pump seal tanks and for crystalliser cooling.	The use of raw water as makeup has been replaced with injection cooling water. A closed circuit cooling system for the vacuum pumps and crystallisers is under review.

Seal well level control and overflows Pongola has a subterranean seal well with automatic level control to maintain condensers' barometric seal. Poor level control results in overflows of water to the ETP. Excessive foaming leads to incorrect level measurement. Starting and stopping of the injection and spray water pumps causes overflows, especially during power failures. Blocked spray nozzles on the spray pond have an impact on the seal well level control which results in overflows.	Close monitoring and calibration of level probes and the slug dosing of antifoam is carried out. The spray nozzles in the spray pond have been unblocked and regular monitoring and maintenance is now carried out. Correct pump start/stop procedures have been reinforced to prevent overflows.
Spray pond overflows Spray pond overflows end up in the ETP. Measurements of the spray pond overflow during peak operation indicated overflows as high as ±60 m^3/h.	An integrated water management approach was adopted. Overflows from the pond were diverted to irrigation for on the Pongola mill estate parks and gardens. A phased program to install a similar irrigation system on other areas of the mill estate is being planned, with long-term plans to extend irrigation to the private cane fields in close proximity to the mill.
Caustic boiling Spent caustic from boiling out evaporators on shutdown was drained into the ETP.	Used caustic is now returned via the caustic reclaim system for reuse. Caustic strength is closely monitored to use the minimum quantity of caustic make-up. Stop-day evaporator flushing water is returned to the spray pond.
Aeration plant maintenance Frequent failures of floating aerator gearboxes were experienced in the oxidation pond (Dam 3). Two fixed disc aerators were in a state of collapse in the Pasveer ditch as shown in Figure 7. The third aerator in the Pasveer ditch was out of commission for an extended period. The outlet weirs and valves were dysfunctional. Due to failures of the valves, active solids were lost from this part of the ETP.	The maintenance on the ETP equipment was given high priority. All three floating aerator gearboxes were refurbished. The third disc aerator on the Pasveer ditch was refurbished. New set of discs were fitted to all three floating aerators and re-commissioned as shown in Figure 11. The outlet weirs and valves were restored to their original functionality.

Other improvements

The utilisation of a flow model to monitor and optimise the ETP is regularly being applied to ETP operations. This model highlighted excessive power input to the Pasveer ditch, which would have had negative effects on retention of biological sludge. The excess power was due to the retroactive installation of two additional aerators for a ditch designed to run with a single aerator. The optimum power is calculated from knowledge of typical sludge concentrations and the potential COD abatement by the sludge. This is compared with the power required to supply oxygen for the required COD abatement. The calculations suggest that the sludge (at target concentration) is capable of removing 400 kg COD/d (if the ditch is free of silt) whereas the power input is sufficient for 522 kg/d. The limiting factor is the sludge concentration, which means that the power input is excessive. When inert silt occupies

50% of the ditch, the power input is approximately 2.5 times the requirement. Excessive agitation caused by the excessive power results in poor performance of the clarifiers with consequential reduction in sludge concentration, and preferential retention of inert silt. The installed power input per unit volume is approximately three times that of the Noodsberg Pasveer ditch.

The inlet/outlet arrangements between dams 1, 2 and 3 caused short-circuiting of effluent through the dams which significantly reduced their respective treatment capacities and also resulted in carry-over of solids. The old flow arrangement is shown in Figure 8. It is planned to reposition these during de-silting work. The new arrangement is shown in Figure 9. Corrections have already been implemented on outflow from Dam 1 to Dam 2.

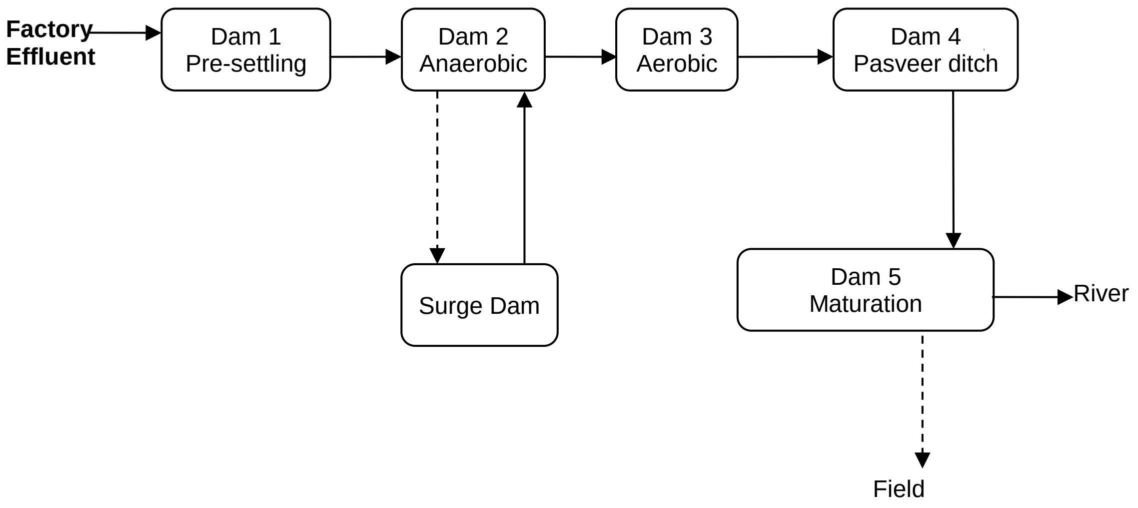


Figure 8. ETP old effluent flows from Dams 1 to 5.

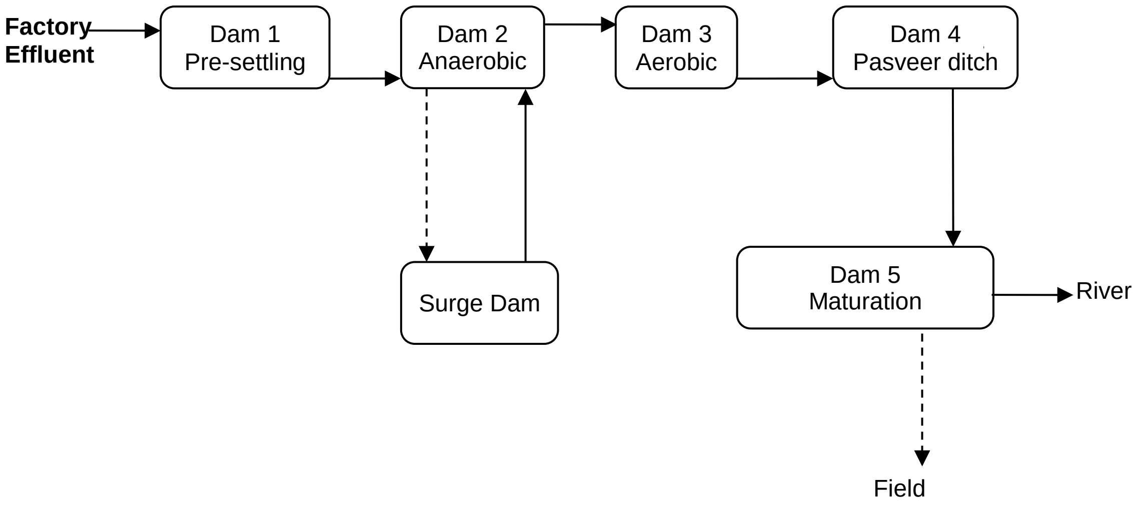


Figure 9. Current effluent flow arrangement.

Figures 10 and 11 show one of the floating aerators being removed from the aeration pond and the completely repaired aerator just prior to re-installation.

Figure 10. Floating aerator being removed for refurbishment.

Figure 11. Refurbished aerator from the aeration pond.

Discussion of results

Pongola sugar mill's efforts to rehabilitate the ETP has resulted in a significant improvement in the performance of the plant. Figure 12 shows improving trends for percentage removal and COD trends over the past five years. The percentage COD removal improved to greater than 90%, resulting in the final effluent quality meeting specifications.

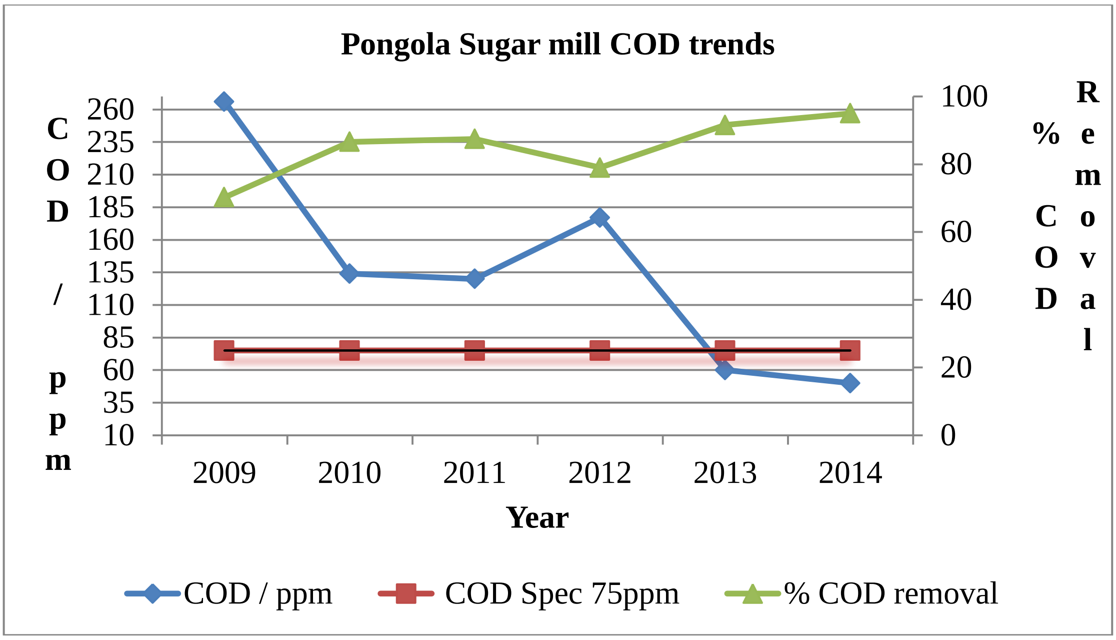


Figure 12: Effluent treatment plant performance trend over a five year period.

The outcome of the remedial work has revealed that the ETP is robust and works well, even at high hydraulic loading, provided the system does not become contaminated with solid ash. The recovery in performance of the plant was fairly quick once sludge removal was completed. This can be seen from Figure 12.

The hydraulic loading showed a decline over four seasons as shown in Figure 13. A slight increase was noted in 2013. This was traced to leaks from the subterranean injection water piping. Although a section of the pipe was repaired during the last off-season, further work on this system is still necessary to completely eliminate this source of hydraulic loading.

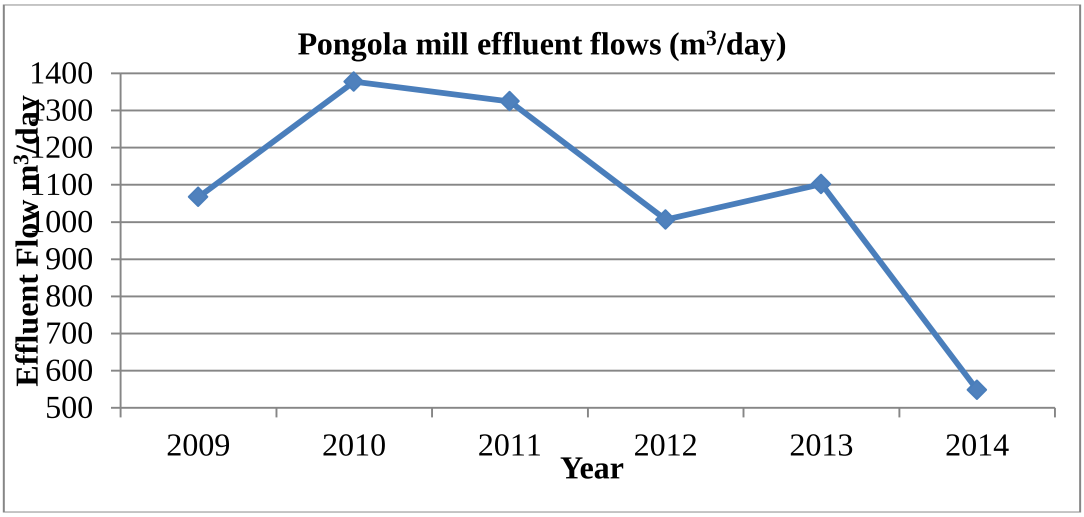


Figure 13. Effluent hydraulic loading over a five year period.

Note that the flow in Figure 13 represents flow measured from the factory and excludes the spray pond flow.

Factory effluent volume represents approximately 40 to 50% of the total effluent inflow with the spray pond overflow contributing an additional 60 m^3/h at peak.

The ETP has performed reasonably well since 2014/15 season started. Suspended solids are also within statutory requirement of less than 25. The actual pH of the final effluent is well within the required pH of 5.5-9.5. Figure 14 shows pH and COD for the current 2014/15 season.

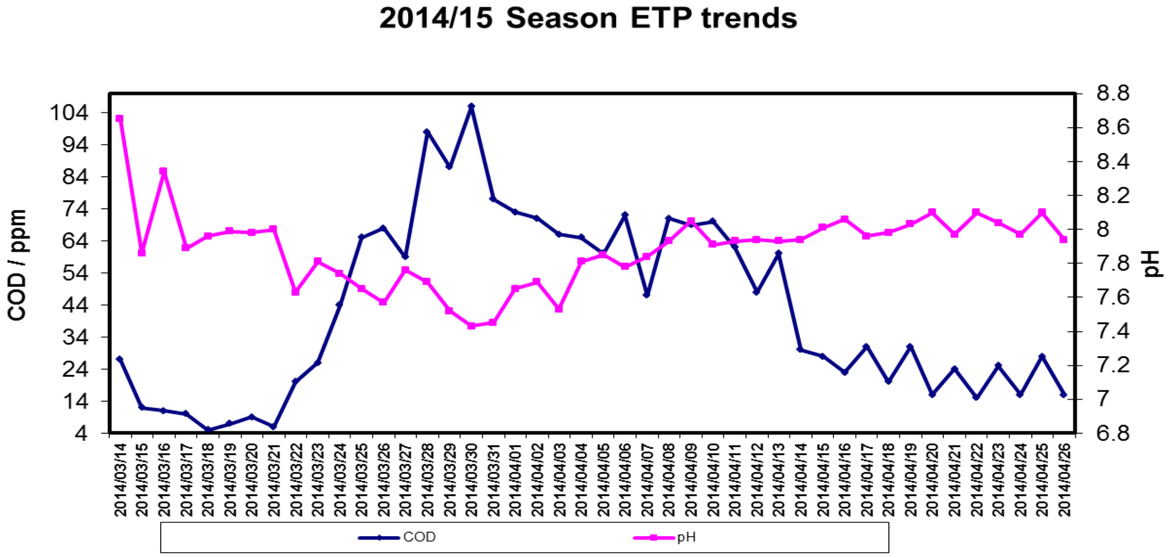


Figure 14. Chemical oxygen demand (COD) and pH trends for the 2014/15 season.

It is important to note that the management of sugar mills should appreciate that the ETP should not be used as a dumping ground for waste produced in the mill. It is a sensitive biological process and, for successful operation, careful control and maintenance are necessary (Simpson and Hemens, 1978).

Cost

The actual cost of rehabilitation and maintenance of the ETP over the past five years is shown in Table 5. The average cost of sludge removal was R100/m^3, with an average cost per year of R461 936.

Table 5. Effluent treatment plant (ETP) de-sludging cost.

Dam rehabilitation costs Pongola ETP			
Year	**De-sludging/excavation programmes**	**Estimate sludge volume (m^3)**	**Total costs (Rand)**
2010 and 2014	Dam 3	2749	89 125
2011 and 2014	Dam 1	2820	955 411
2012	Dam 2	3805	221 451
2013	Dam 4	900	139 800
2013	Dam 5	12764	903 892
	Total	23038	2 309 680
Average cost of sludge removal per m^3			100
Average cost per year			461 936

Continuous improvement challenges

- The need for continuous monitoring of the various effluent streams is considered to be vital. The installation of flow meters and auto samplers will enable tighter control and monitoring of the ETP and will be completed during the next phase of the programme.
- The regular and routine monitoring and control of the following key control parameters is considered to be vital: flow rates, nutrient content, COD loading, MLSS, SVI and suspended solids. A simple computer spreadsheet for the Pongola ETP was used to assist in achieving better control and improved monitoring of the ETP (Appendix 2).
- The long term plan at Pongola is to achieve zero effluent discharge. It is envisaged that this could be achieved through recycling treated effluent or excess condensate for irrigating the factory estate. The feasibility of irrigating cane fields in the surrounding areas is being investigated.
- The challenge facing the Pongola Sugar mill is the prevention of ash ingress to the ETP. While much effort has been placed on solving the problem at its source, the feasibility of installing a silt trap between the factory and the ETP is presently being investigated. The cost of such a system can be benchmarked against the R100/m^3 cost of excavating sludge from the dams. More importantly, it does not involve disruption to the system caused by removal of valuable anaerobic sludge from the dams. Depiction of a typical silt trap arrangement is shown in Appendix 1.

Attempts to fully de-sludge Dam 5 were hindered by strong seepage from the treatment dams upstream. This raised concerns about the integrity of dam sealing possibly allowing seepage to reach the river. This will require a critical review of the construction and taking of ground water samples to ensure compliance with legal requirements. This will be done during the next phase.

Conclusions

The investigation to identify the reasons for drop-off in performance at the Pongola sugar mill ETP has led to the implementation of remedial action resulting in the following:

- Identification and minimisation of effluent generated.
- Improvement in the final treated effluent quality.
- Opportunity to further improve and enhance the ETP.
- Mitigation of the risk of discharging out-of-specification effluent and thereby ensuring compliance with local regulations.

Close monitoring of the ETP is considered to be the key issue for successful performance of the plant.

Acknowledgements

The authors would like to thank Pongola sugar mill management for giving permission and encouragement to publish this paper, Dr BS Purchase for his invaluable technical inputs and suggestions and Mr Ish Singh for his continued contribution and support throughout this paper.

REFERENCES

Bruijn J (1975). Treatment of sugar factory effluent in biological trickling filters. *Proc S Afr Sug Technol Ass* 49: 22-28.

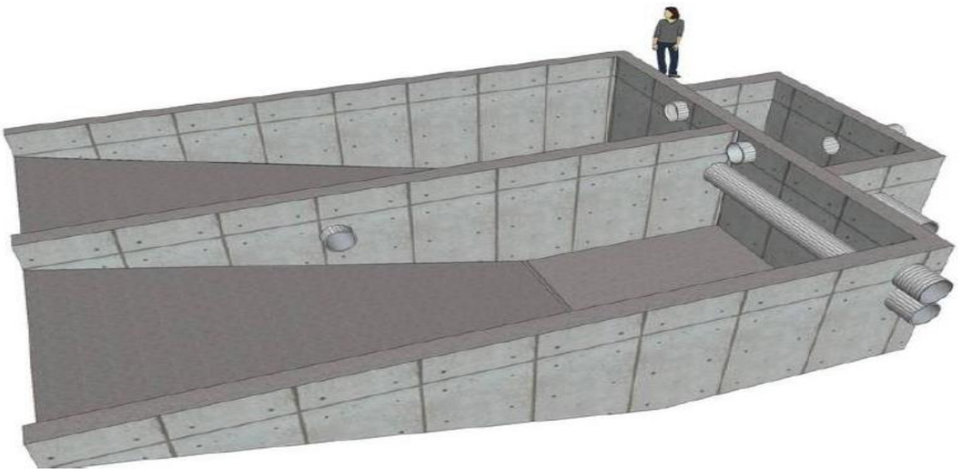
Government Gazette (1998). No. 20256. General authorisations in terms of section 39 of the National Water Act. (Act No. 36 of 1998), No. 1191 (8 October 1999).

Purchase BS and Perrow S (1983). Suggestions for improving anaerobic digestion of sugar mill effluent. *Proc S Afr Sug Technol Ass* 50: 242-245.

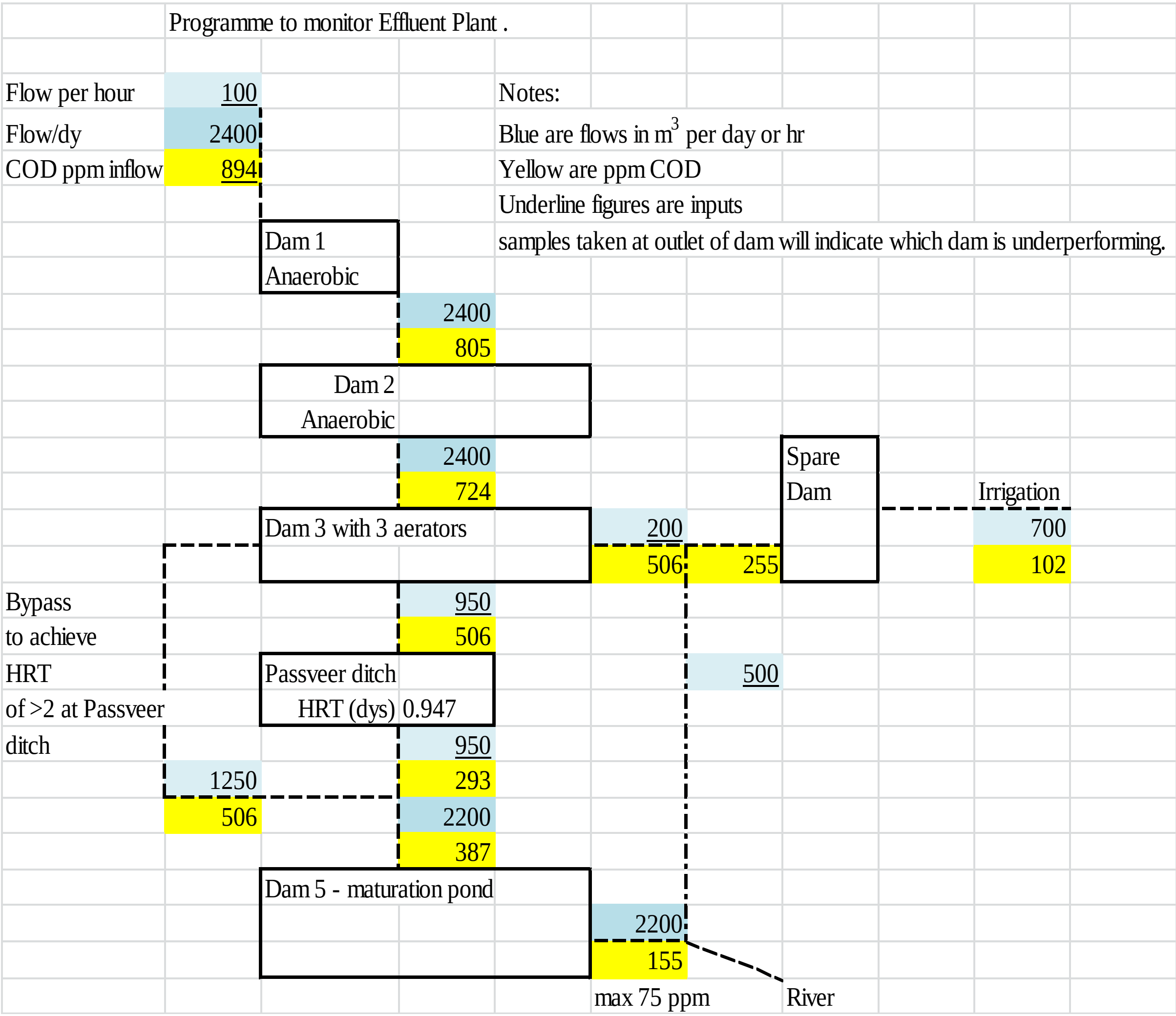
Simpson DE and Hemens J (1978). Activated sludge treatment of sugar mill/wattle bark mill effluents at Dalton, Natal. *Proc S Afr Sug Technol Ass* 52: 20-25.

Appendix 1

Sediment Control Systems – Silt Traps



Appendix 2
Overview of Dr BS Purchase's flow model



Volumetric capacity of dams				
		Original (m^3)	**% silted**	**Operating volume (m^3)**
	Dam 1	5200	54	2392
	Dam 2	11288	34	7450
	Dam 3	12606	22	9833
	Pasveer ditch	1800	50	900
	Maturation	42709	30	29896
	Spare dam	8000	25	6000
Dam 1		**m^3/h**	**m^3/d**	
	Incoming effluent	100	2400	2392
	Incoming COD (ppm)	894		
	Total incoming (kg COD/d)	2146		
	Load (kgCOD/m3/d)	0.90		
	Abatement %	10		
	Total out (kg COD/d)	1931		
	Outlet effluent COD (ppm)	805		
	HRT (days)	1.0		

Volumetric capacity of dams				
		Original (m^3)	**% silted**	**Operating volume (m^3)**
Dam 2		**m^3/h**	**m^3/d**	
	Incoming effluent	100	2400	7450
	Incoming COD (ppm)	805		
	Total incoming (kg COD/d)	1931		
	Load (kgCOD/m^3/d)	0.26		
	Abatement %	10		
	Total out (kg COD/d)	1738		
	Outlet effluent COD (ppm)	724		
	HRT (days)	3.1		
Dam 3		**m^3/h**	**m^3/d**	
	Incoming effluent	100	2400	9833
	Incoming COD (ppm)	724		
	Total incoming (kg COD/d)	1738		
	Total day kg COD reduction	523		
	Total out (kg COD/d)	1215		
	Outlet effluent COD (ppm)	506		
	HRT (days)	4.1		
	% Reduction	30		
Passveer ditch			**m^3/d**	
	Incoming effluent		950	900
	Incoming COD (ppm)	506		
	Total incoming (kg COD/d)	481		
	Abatement potential (kg COD/d)**	203		
	Outlet load (kg COD/d)	279		
	outlet effluent COD (ppm)	293		
	HRT (days)	0.95		
Spare dam			**m^3/d**	
	Incoming effluent		700	6000
	Incoming COD ppm	255		
	Total incoming (kg COD/d)	179		
	Load (kg COD/m^3/d)	0.03		
	Abatement %	60		
	Total out (kg COD/d)	71		
	outlet effluent COD (ppm)	102		
	HRT (days)	8.57		
Maturation			**m^3/d**	
	Incoming effluent		1700	29896
	Incoming COD (ppm)	387		
	Total incoming (kg COD/d)	658		
	Load (kg COD/m^3/d)	0.02		
	Abatement %	60		
	Total out (kg COD/d)	263		
	Outlet effluent COD (ppm)	155		
	HRT (days)	17.59		

**Based on power input and MLSS content