Activated Sludge System with High Effluent Quality and Minimal Sludge Production.

Mikkel Mandt and Howard Rundle*
**Fluidyne Corporation, 2816 West First St., Cedar Falls, Iowa IA 50613 USA*

ABSTRACT

The paper describes the ISAM™ process of activated sludge treatment. This is a version of the activated sludge process which has been developed in the USA and is capable of producing tertiary quality effluents with minimal sludge production. The system is particularly suited to small works as a package plant. The system is based on a sequencing batch reactor with fixed decanter and jet aeration. By the use of anaerobic and anoxic zones a very stable and efficient system is achieved. Sludge is broken down both aerobically and anaerobically. Case studies from three operating plants are presented.

INTRODUCTION

A major problem with activated sludge plant operation is disposal of the waste activated sludge generated in the process. This sludge is low in solids content, (0.5% to 1%), is difficult to thicken, and may become malodorous if not aerated. Options to reduce sludge production usually involve reducing the sludge loading so that solids are burned off by aerobic digestion. This results in a large plant size and incurs high energy costs for aeration. In addition the low F: M ratio may result in a poor-settling sludge, with consequent loss of solids in the effluent. Particular difficulties have occurred with package activated sludge plants, some claims by manufacturers of low desludging frequencies have proved to be over optimistic.(1) In particular these plants have suffered problems of loss of solids during peaks in flow.

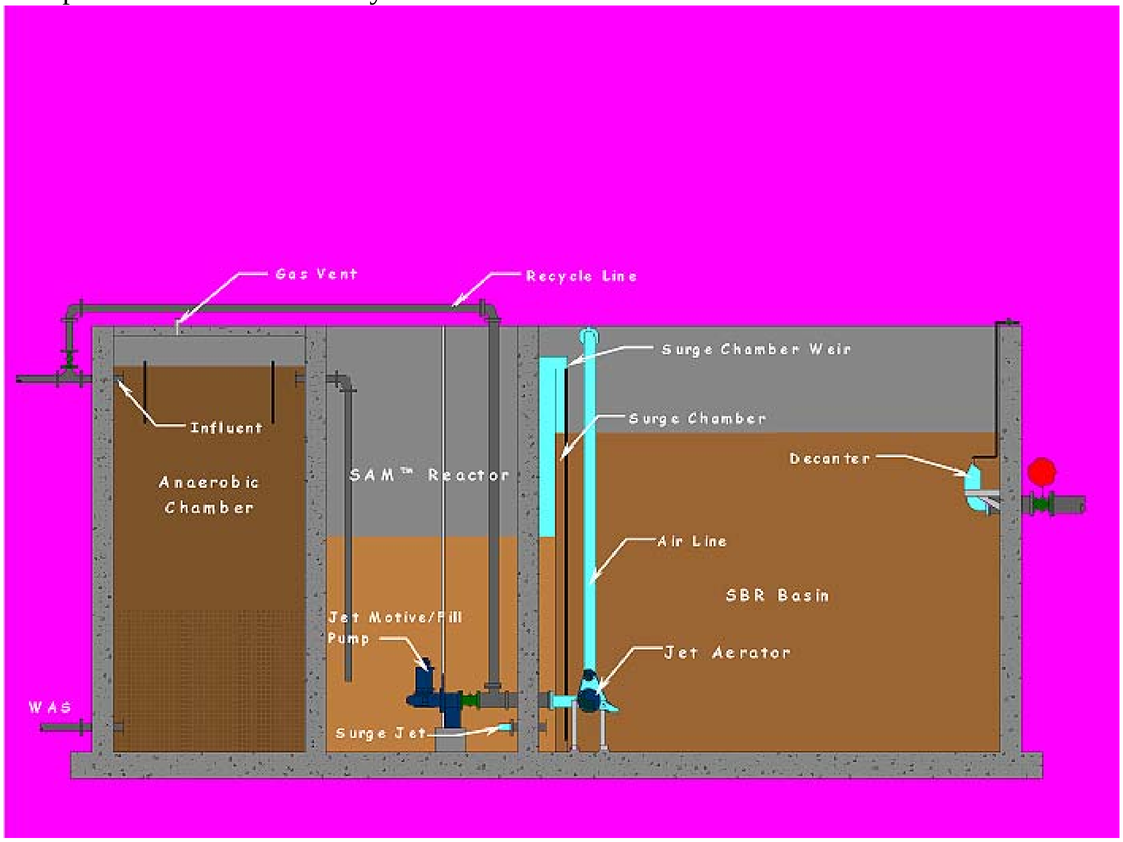
The following paper describes the ISAM™ process, which has been developed to overcome problems encountered with conventional package activated sludge plants.

DESCRIPTION OF THE ISAM™ PROCESS.

The basis of the ISAM™ process is a single cell sequencing batch reactor. (SBR)
In this the sewage is treated batchwise, with aeration being followed by a period of quiescent settlement. Key components of the SBR are shown in figure 1 They are

1. The decanter
2. The jet aerator
3. The SAM™ tank
4. The surge chamber and surge chamber weir
5. The anaerobic chamber
6. The recycle line

Figure 1
Components of the ISAM™ System



1. *Decanter*

The treated effluent is removed by a novel fixed decanter, with no moving parts in the tank. When the tank is being mixed, the decanter is sealed by an air seal. This prevents mixed liquor entering the decanter. After the settlement period is complete an air relief valve is opened and allows effluent into the decanter. The outlet valve opens and the treated effluent is discharged. The decant is terminated just before the lip of the decanter to prevent any scum being drawn into the effluent. At the end of the decant the outlet valve and air relief valve are closed. This seals the air in the decanter to prevent ingress of mixed liquor

2. *Aeration*

Aeration and mixing are provided by a jet aerator[2], but this is installed in a novel way. The jet aerator is an efficient aeration and mixing device .In operation mixed liquor is pumped through a venturi jet. Air is entrained in the jet and is sheared into small bubbles in the jet. The stream of mixed liquor and bubbles is forced into the aeration tank where mixing and aeration take place. This system of aeration is very efficient and the efficiency is not significantly reduced in dirty water conditions. (Alpha factor effects are minimal.) This compares favourably with fine bubble diffusers where oxygen transfer efficiency in sewage may be less than half of that in clean water.
In the configuration used in this process the jet motive pump is also used to transfer mixed liquor into the SBR.

3. *SAM™ tank.*

The SAM ™ tank functions as both a balancing tank and an anoxic zone. It is located before the SBR tank and receives the incoming flow. When the level in the SAM tank reaches a preset level the jet aerator motive pump starts and transfers the accumulated feed to the SBR tank via the jet aerator.

4. *Surge chamber and surge chamber weir*

This is located at top water level in the SBR tank, and is connected to the SAM™ tank via the surge jet. When the SBR tank is full, the contents overflow via the surge chamber and surge jet into the SAM™ tank. This causes very intense mixing in the SAM™ tank

5. Anaerobic chamber.

This is simple tank with inlet and outlet baffles and an overflow leading to the SAM™ tank. The hydraulic retention period is several hours. A connection for removal of waste sludge is provided at the bottom of the tank.

6. *Recycle Line.*

A recycle line is provided to divert some of the flow from the jet motive pump to the anaerobic tank. The proportion of the flow bled off is fixed and is set on start up.

OPERATION OF THE ISAM™ SYSTEM.

Crude sewage enters the anaerobic chamber. Solids settle in the chamber and the settled sewage enters the SAM™ reactor. This is an unaerated chamber, which will contain some activated sludge. The level in the chamber rises and at a pre-set level the combined jet motive and fill pump starts and transfers the mixture from the SAM™ tank to the aeration tank via the jet aerator. When the aeration tank is filled the mixed liquor overflows the surge weir and returns to the SAM™ tank via the surge jet. This causes intense mixing in the SAM tank, which then functions as an anoxic zone. The mixed liquor is then subjected to alternating periods of aerobic and anaerobic conditions. After a pre-set period, the pump is stopped and the mixed liquor in the aeration tank is allowed to settle. Settlement takes place in totally quiescent conditions. At the end of the settlement period the supernatant effluent is removed by the decanter. During the settlement and decanting periods the SAM™ tank acts as a balancing tank. Since it contains activated sludge from the previous cycle, the contents are subjected to denitrification and high floc loadings. When the aerator is operating, a small amount of mixed liquor is diverted at a controlled rate to the inlet of the anaerobic chamber. These solids settle within the anaerobic chamber. In this chamber some decomposition of the solids takes place to give simpler, soluble compounds such as fatty acids. The mixed liquor flow from the recycle line acts as a form of elutriation, flushing solublised material from the anaerobic chamber to be degraded in the aerobic reactor.

The net result of the above is as follows.

1. The activated sludge is subjected to periods of high floc loading, inhibiting the growth of filamentous organisms and giving a well settling sludge.
2. The system is ideal for denitrification, which prevents rising sludge and reduces energy costs by recovery of oxygen.
3. The destruction of sludge solids results in a very low sludge yield.
4. The presence of readily biodegradable COD in the anaerobic tank effluent and the anaerobic/anoxic periods in the SAM™ tank favour the growth of organisms responsible for biological phosphorus removal.

5. Any scum which forms in the aeration tank overflows the surge weir and is mixed in the SAM™ tank. It is either broken down aerobically in the react phases or is transferred to the anaerobic tank for degradation or removal.
6. Settlement takes place in totally quiescent conditions. There is no danger of solids being scoured from the plant during high flow events.

In its simplest form the ISAM™ process consists of a single tank package plant. The only moving part is the jet motive/fill pump, which is a conventional submersible pump mounted on rails. Two pumps are provided on a duty/standby basis.

There are over 150 SBR plants throughout the world which employ the fixed decanter and jet aerators. At present there are about 30 plants employing the ISAM™ technology. Case studies from 3 are given below.

CASE STUDY 1 CONO CHRISTIAN SCHOOL, WALKER, IOWA USA
This installation was started up in the winter of 1998. It consists of a single package unit treatment plant measuring 9.75m long by 2.6m wide by 3.2m high. The unit is placed on a concrete slab and covered by a simple timber framed building. In winter the building is heated sufficiently to maintain the temperature just above freezing. Design and operating parameters for the plant are shown in table 1.

Table 1 Cono Christian School ISAM™ plant Design Parameters.

Parameter	Value	Units
Population served	200	Residents
Average Flow	19	M^3/d
Maximum flow	95	M^3/d
Feed BOD	200	Mg/l
Feed TSS	200	Mg/l
Feed ammonia	30	MgN/l

The performance parameters for the plant for the first 18 months of operation are shown in table 2

Table 2 Cono Christian School ISAM™ Plant Operating results

Parameter	Value	Units
Effluent cBOD	3	Mg/l
Effluent TSS	3	Mg/l
Effluent Ammonia N	<1	MgN/l

All of these values are less than the permit values, which are 25mg/l for BOD, 30mg/l for TSS and 3 mgN/l for ammonia.

The only moving parts in the plant are two 6 kW jet aerators, which are operated on a duty/standby basis.

The plant was started up in December 1998. The plant operated for 18 months before desludging was necessary. In June 2000, $9.5m^3$ of sludge were removed from the plant. This had a total solids content of 11.93% and only 29.74% was volatile.

This is equivalent to an operating period of about 540 days. The daily sludge production is equivalent to17.6 litres or 2.1kgds/d. The long term average flow to the plant was 22.8 m^3/d. Sludge production from a similar, conventional plant would be expected to be10 to 14 kgd.s./d. This would have a volume of between 200l and 1400l depending upon solids content.

The most recent information from the plant was received in November 2001. Effluent quality continued to comply with permit values and no further sludge had been removed.

CASE STUDY 2 JOHN WOOD SCHOOL MERRILLVILLE, INDIANA USA

This plant was started up in August 1999. This consists of a single package treatment plant, 6.25m long by 2.44m wide and 3.5m high. It is buried in the ground to the top of the unit. There is no other protection from the severe winters, where temperatures can fall as low as -25°C. The plant treats the sewage from a population of between 400 and 500 students and staff who attend during the working day only. (5 days per week, 8 to 10 hours per day). The design average flow is 25 m^3/d. On weekdays over 50% of the flow arrives between 11:00 hrs and 14:00 hrs.

The consent conditions are shown in table 3

Table 3 John Wood School Permit Conditions

Parameter	Monthly Average	Weekly Average
CBOD	10mg/l	15mg/l
TSS	10mg/l	15mg/l
Ammonia Summer	1.2mgN/l	2.9mgN/l
Ammonia Winter	1.3mgN/l	3.1mgN/l

The operating results for the period between the end of August 2000 and May 2001 (33 results) showed that there were no individual samples which exceeded the weekly average limits. The overall average effluent TSS was 7.4 and the ammonia 0.76mg/l. The plant operated with a mixed liquor TSS of between 2051mg/l and 5099 mg/l (average 3293mg/l).

During the early months of operation it was noted that there was some “bleed through” of nitrogen into the effluent. This was due to the large proportion of flow entering the plant in the middle of the day. The operational regime was altered using simple time clocks to optimise treatment during the high load periods.

During the first year of operation no sludge was removed from the plant.

CASE STUDY 3 SEPTAGE PRETREATMENT PLANT, VOLUSIA COUNTY, FLORIDA USA

This is a plant designed to pre treat septic tank waste before discharge to an existing treatment facility. The design parameters are:

Table 4, Volusa County, Septage Pre-treatment Plant Design Parameters.

Parameter	Value	Units
Average Flow	8	M^3/d
CBOD	3200	Mg/l
TSS	700	Mg/l
Required Effluent cBOD	180	Mg/l
Required Effluent TSS	220	Mg/l

In the first year of operation the plant produced an effluent well within its design capability. The average of the analytical results is shown in table 5.

Table 5 Actual Operating Data for Volusia County Septage Pre-treatment Plant.

Parameter	Influent	Effluent	Units
CBOD	3879	7	Mg/l
TSS	506	4.1	Mg/l

VISUAL AMENITY

All of the plants described are prefabricated and delivered to site complete. They can either be buried in the ground (as at John Wood School) or installed in a suitable small building. In some cases the building is indistinguishable from others on the development.

FURTHER DEVELOPMENTS

Further development of the process is underway to apply it to larger installations, both in new build plants and as retrofit to existing installations. This includes developments for reducing sludge production from existing activated sludge plants.

CONCLUSIONS

The ISAM™ process is a novel process employing a modified anaerobic stage providing optimal operating conditions for the activated sludge process. In particular the process is capable of producing an effluent of consistently high quality, with very low sludge production. The equipment is very simple and is easily maintained. This makes it ideal for package plant as it can be prefabricated and can be hidden underground or within suitable buildings.

The process is adaptable for a range of sizes and will be applied in new installations as well as being retrofitted to existing plants.

REFERENCES

1 CIWEM. Handbook of UK Wastewater Practice, Activated Sludge Treatment CIWEM 1997,p131
2 Water Pollution Control Federation and American Society of Civil Engineers Manual of Practice FD-13 Aeration WPCF/ASCE 1988, p30