

ECO SYSTEM PLUS™ (ESP) STUDY

HERTEN - WESTERHOLT WASTEWATER TREATMENT PLANT GERMANY

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SUMMARY PRESENTATION

Preliminary Results
of the
EcoSystem Plus® (ESP) Study
Herten- Westerholt Wastewater Treatment Plant
Germany

by
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(5/8/98)

INTRODUCTION

EcoSystem Plus (ESP) is a product manufactured by Neozyme International Inc. (Neozyme) of Aliso Viejo, California. ESP has been formulated to improve the efficiency of wastewater treatment through the use of novel bio-organic catalysts (BOCs). ESP was recently evaluated over a five month interval at a municipal wastewater treatment plant (MWTP) in Westerholt, Germany. This evaluation was performed by Deutsche Klar- und Entsorgungs- Gesellschaft mbH (DKE) of Dusseldorf Germany. The data in this report are presented with the permission of DKE.

PLANT DESCRIPTION

The Klarenlage Herten-Westerholt (Herzen-Westerholt Sewage Plant) is located in the small town of Westerholt, about 15 kilometers north of Essen, a major industrial center of west central Germany. The Klarenlage Herten-Westerholt (Westerholt) is operated by the Emschergenossenschaft Lippeverband, an organisation which operates more than 60 municipal wastewater treatment facilities within the Ruhr area of Germany.

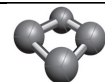
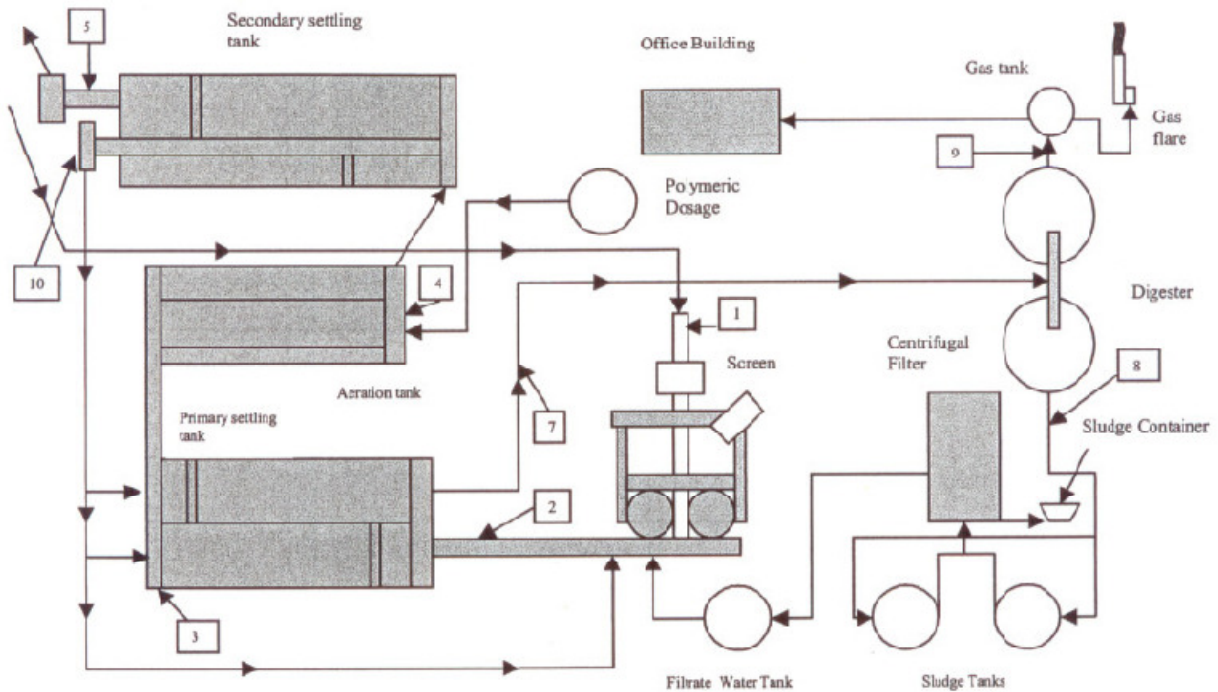


FIGURE 1



Westerholt is an activated sludge plant with wasted secondary sludge returned to the primary settling tank. Figure 1 is a schematic diagram of the Westerholt plant and Table 1 summarizes the operational parameters for the plant. The plant consists of a Primary Settling Tank, an Aeration Tank, and a Secondary Settling Tank having volumes of 750 cubic metres (m^3), 1620 m^3 , respectively, for a total plant volume of 4290 m^3 .

The plant serves approximately 40,000 population equivalents (39,000 inhabitants) located within a 5 square kilometres area. The plant receives wastewater at an average rate of about 250 cubic metres per hour (m^3/h) for a daily average of about 6,000 cubic meters per day (m^3/h) (1.59 million gallons per day (MDG)). Based on the design volume of Westerholt and the average hydraulic load to the plant, the average waste water treatment time is about 17.2 hours (detention time - plant volume/wastewater volume). However, during the peak flow period (early afternoon) detention time can be as little as nine hours.

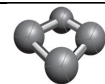


TABLE 1

Plant Parameters during ESP Evaluation

Population	39,000 inhabitants in a 486 hectare area
Average Inflow	250 cubic meters per hour (m ³ /h)
Average COD Load	800 milligrams/liter (mg/L)
Estimated BOD Load	400 mg/L
Primary Sludge Production	45 cubic meters per day (m ³ /d)
Methane Production	700 m ³ /d
Plant Volumes:	
Primary Settling Tank	750 m ³
Aeration Tank	1620 m ³
Secondary Settling Tank	1920 m ³
Average Detention Time	17.2 h

Sludge resulting from the wastewater treatment process is pumped into two Anaerobic Digesters, each with a volume of 1000 m³, where methane gas is produced from the anaerobic digestion process. With both digesters in use, the anaerobic digestion process has a duration of about 30 days. However, during a portion of this study, only one digester was used and the process time was reduced to about 21 days. Solids remaining after the digestion process are dewatered by centrifugation and disposed of by on-site land application.

Wastewater entering the plant has a COD of about 800 milligrams per liter (mg/L). Based on an accepted relationship between COD and BOD, this is equivalent to a BOD of about 400 mg/L. Effluent wastewater from the plant has a COD of about 32 mg/L. The volume of sludge passing through the anaerobic digesters is approximately 45 m³/day, resulting in a combined production of about 700 m³/day methane from the plant's two anaerobic digesters.

Table 2 is a key to the critical points highlighted in the process diagram shown in Figure 1. The significance of each of these critical points is listed below:

1. The temperature of wastewater coming into the plant is measured at this location.
2. The Neozyme ESP treatment was introduced at this location just before the primary settling tank.
3. As wastewater is pumped from the Primary Settling Tank, samples are collected for the following analytical determinations:
 - Total Suspended Solids (TSS);
 - Chemical Oxygen Demand (COD);
 - Ammonia Nitrogen CMf4-N); and
 - Phosphorus as Phosphate (P04-P)
4. As wastewater leaves the aeration tank, polymer is added to promote settling in the Secondary Settling Tank. The following analytical determinations are made at this location:
 - Aeration Power;
 - Dissolved Oxygen (DO);
 - TSS;



- Activated Sludge (Biomass);
- NH₄H; and
- P₀₄-P

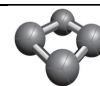
TABLE 2

Key Measurement Locations

(as shown Figure 1, the process diagram)

Location	Measured Parameters
1	Temperature
2	ESP Dosage
3	TSS, COD, NH ₄ -N, P ₀₄ -P and N
4	Polymer Dosage, Oxygen, TSS, NH ₄ -N, P ₀₄ -P, Compressed Air, and Sludge Volume
5	TSS, COD, NH ₄ -N, P ₀₄ -P, N, P, and Plant Outflow Volume
6	Active Biomass
7	Sludge Volume and TSS
8	TSS after Anaerobic Digestion
9	Methane and Carbon Dioxide
10	TSS of Returned Biomass

5. Biomass is settled in the Secondary Settling Tank and the following analytical determinations are made as wastewater is discharged from the plant:
 - COD;
 - NH₄-H;
 - P₀₄-P;
 - N;
 - Total Phosphorus (P); and
 - Wastewater Discharge Volume
6. Activated sludge is pumped back to the Primary Settling Tank along a line originating at location 10.
7. Solids consisting of a combination of settled TSS and returned activated sludge are diverted from the primary settling tank to the anaerobic digesters.
8. Solids having undergone anaerobic digestion to produce methane gas are pumped to storage tanks and dewatered by centrifugation prior to on-site land disposal. Sludge volume is estimated by the following determinations:
 - TSS; and
 - Volume of sludge flowing into presses
9. The volume of methane gas resulting from anaerobic sludge digestion is measured at this point. Carbon dioxide (CO₂) is also present as an impurity of the produced methane gas at a concentration of about 32%. This impurity is not removed because the methane gas is not



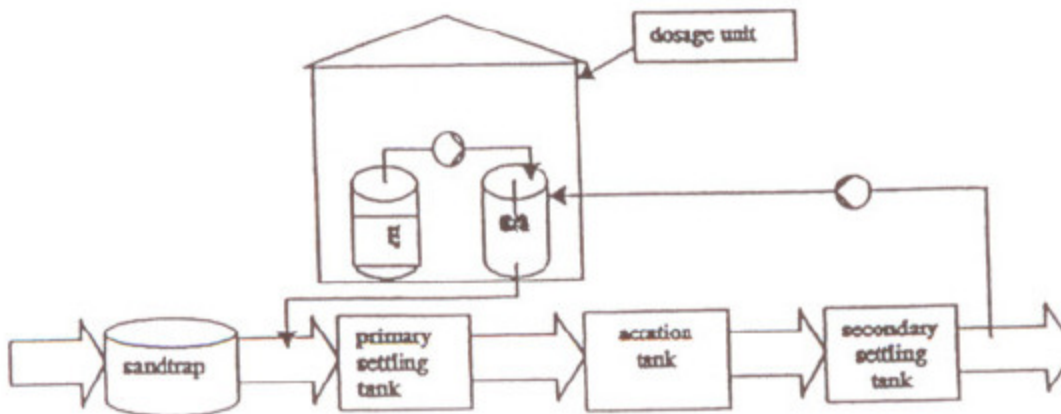
used as an energy source for critical applications such as operating gas turbines or gas motors.

10. Activated sludge is pumped from this point back to the Primary Settling Tank.

ESP TREATMENT PLAN

Based on a review of the Westerholt treatment process, it was determined that ESP should be added to the wastewater just before the primary settling tank as shown at location 2 in Figure 1. Adding ESP at this point facilitated dispersion of the product throughout the plant as well as maximizing the amount of time that each process could be affected by ESP treatment.

FIGURE 2

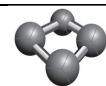


Dosing was accomplished, as shown in Figure 2, by pumping ESP into a mixing vessel using a diaphragm dosaging pump. After mixing with treated wastewater, the diluted ESP solution was transported by gravity into the Westerholt waste stream. ESP dosing was not proportional to flow due to variations in flow rate received by the plant throughout the day. For best results, ESP dosing should be proportional to wastewater flow. However, fluctuations in the flow of wastewater to the plant throughout a day made this impractical at Westerholt.

The initial ESP dosage was 5 parts per million (ppm) delivered as a solution consisting of 1.25 liters (L) ESP diluted with 0.75 L wastewater. After two weeks of treatment, the ESP dosage was reduced to 2.8 ppm (0.7 L/h) and was maintained at this dosage rate for the duration of the study. Westerholt wastewater was treatment with ESP from October 9, 1997 into the first week of March, 1998, when construction work on the primary settling tank interrupted the study.

ESP STUDY RESULTS AND CONCLUSIONS

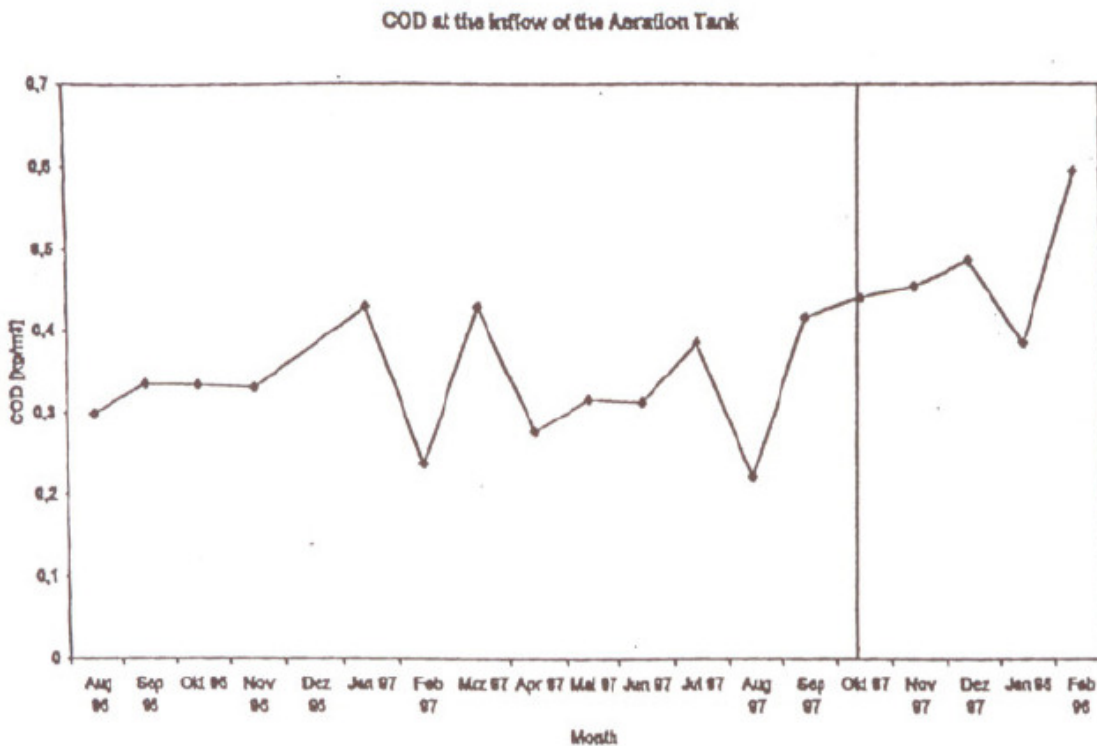
During the 5 month ESP treatment interval, data were accumulated which demonstrate that the efficiency of the Westerholt plant was significantly improved in the following ways:



- A greater portion of influent wastewater solids were converted to a soluble form of COD, which then could be treated in the Aeration Tank through the activated sludge process, thus reducing the load of solids to the Anaerobic Digesters.
- Dissolved oxygen (DO) Levels were increased in the Aeration Tanks where the activated sludge process degraded COD with a greater efficiency than without the ESP treatment.
- Although DO levels were increased in the Aeration Tank, substantially less compressor power was used to maintain aeration at a level required for effective COD removal.
- Aerobic digestion of biomass in the Aeration Tank reduced the volume of returned sludge to the Primary Settling Tank; further reducing the volume of sludge pumped which needed to be treated by anaerobic digestion.
- The total volume of sludge at the end of anaerobic digestion was significantly reduced.

The data supporting these observations has been summarized in a series of figures prepared by DKE. Figure 3 is a graphical presentation of the soluble COD concentrations exiting from the Primary Settling Tank (location 3 on the process diagram). This figure shows a trending increase in COD concentration which coincides with the addition of ESP to wastewater, starting on October 9, 1997.

FIGURE 3



It seems likely that ESP treatment increased the solubility of organic influent wastewater components. An alternative explanation for the observed increase in COD is that the total organic load to the plant increased during this time. If this second possibility were to be true, it becomes much more difficult to explain how the plant became more efficient, as observed during ESP treatment.

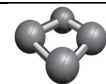
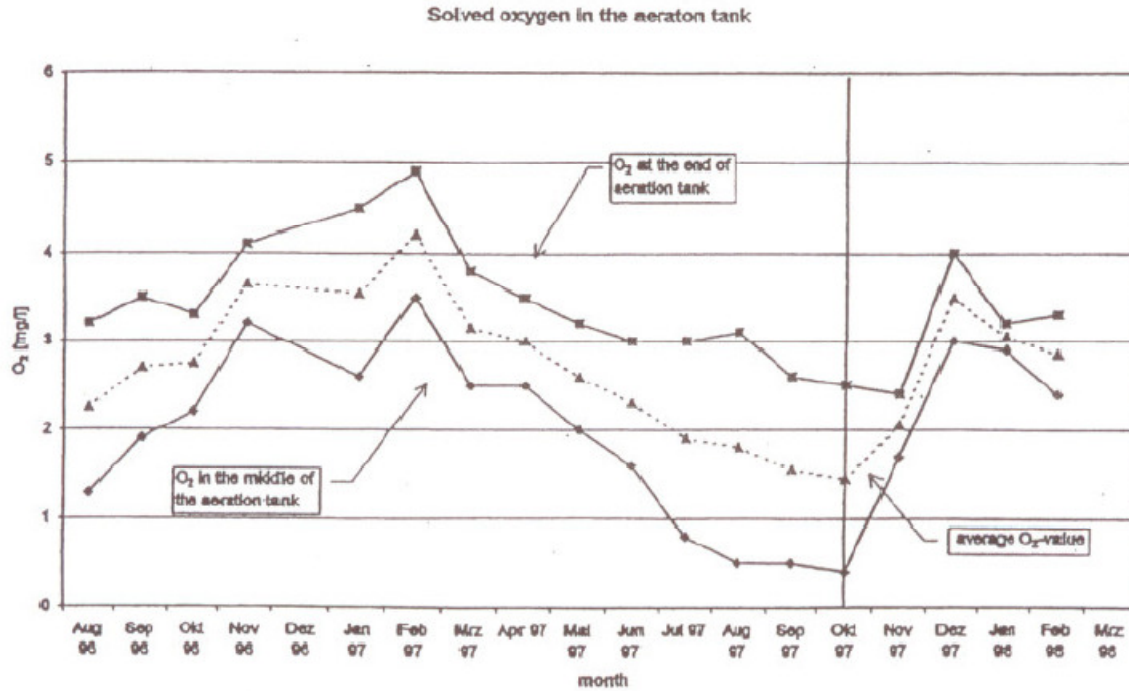


FIGURE 4



ESP improves the efficiency of wastewater aeration through the formation of catalytic microbubbles. Available oxygen concentrations in the Westerholt's Aeration Tank from August, 1997 through February, 1998, are shown in Figure 4. The data presented in this figure indicates that there is a consistent trend towards increased DO starting with the addition of ESP on October 9, 1997. This trend becomes more striking when DO concentrations are plotted together with the kilowatt power required to operate aeration compressors. Figure 5 shows that as oxygen concentrations begin to increase with ESP treatment, the energy required to operate the Aeration Tank blowers inversely declined.

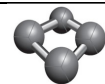
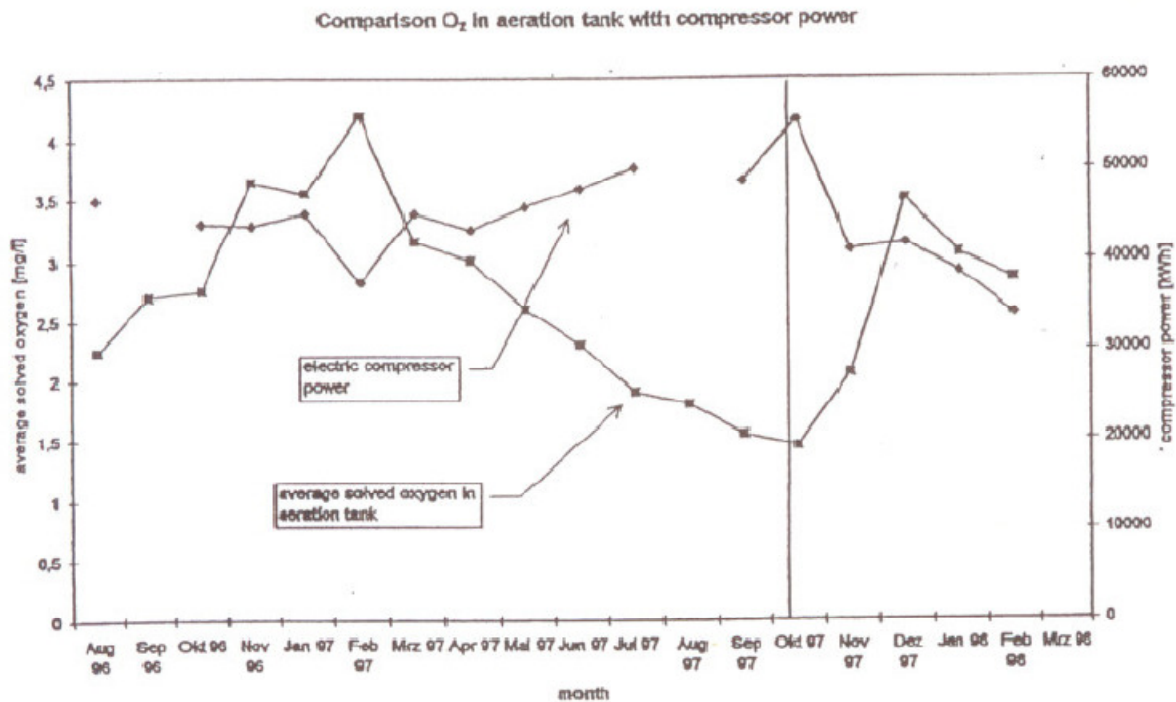


FIGURE 5



The energy required to operate the Aeration Tank blowers is measured as compressor power. Figure 6 is a plot of both the compressor power and aeration required to reduce a given amount of COD. Before ESP treatment, approximately 32m³ of compressed air was required to reduce a kilogram of COD. Beginning with ESP treatment, aeration steadily became more efficient so that by the end of the test 30% less air had to be pumped into the Aeration Tank to maintain COD reductions at pretreatment levels. Data trends suggest that even greater increases in the efficiency of aeration could be anticipated. These results exemplify ESP's ability to increase the mass transfer of oxygen into fluids.

If aeration is made more efficient, it should follow that the compressor power required to aerate should be reduced. Before ESP treatment, the compressor power required to reduce COD was 0.65 kilowatt hours per kilogram of COD (kWh/kg COD). During ESP treatment, this value steadily declined to a low of about 40% (38 kW/kg COD) below the level required for COD removal without ESP treatment. The average reduction in compressor power during the test interval was about 20%.

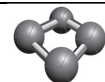
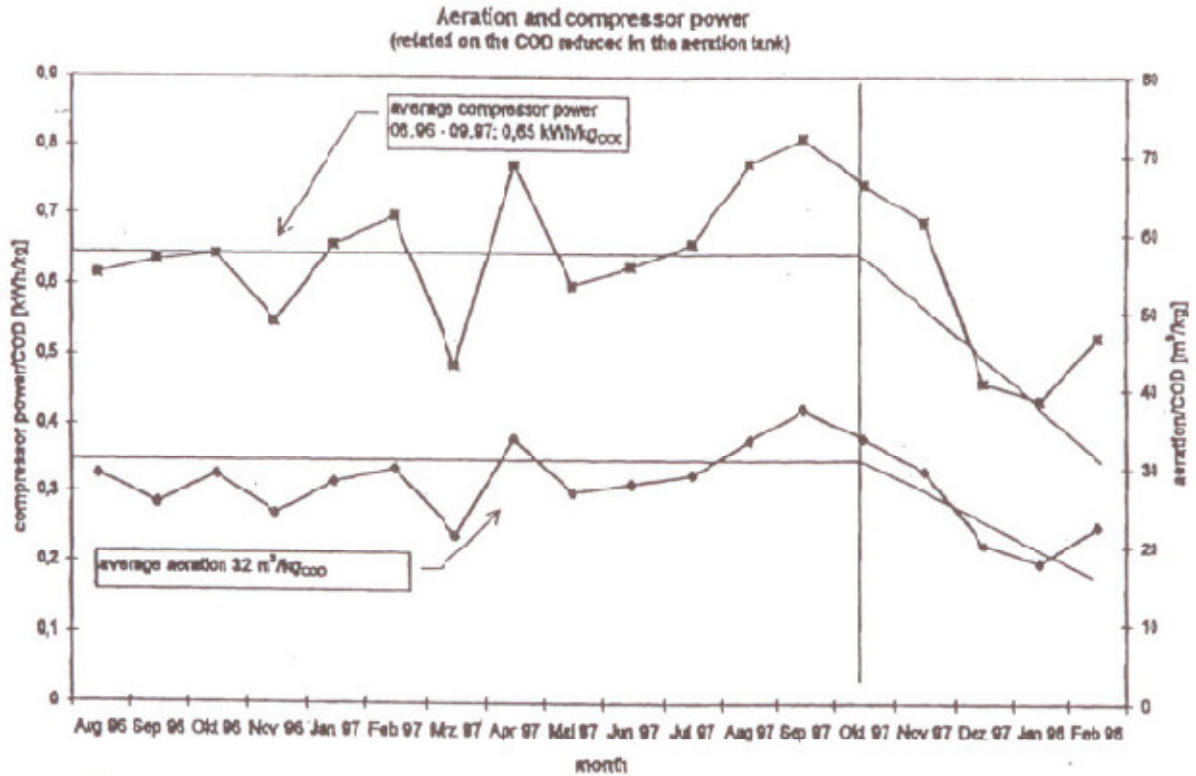


FIGURE 6



According to the local power company, Stadtwerke Herten, the average cost of energy to the Westerholt plant is about 0.18 Deutsch Marks per kilowatt hour (DM/ kWh). Based on this cost of power to reduce COD, the cost of energy at Westerholt would be reduced from 0.12 DM/kg COD to as low as 0.07 DM/Kg COD. Without ESP, the estimated annual cost for compressor power is about 152,713 DM (\$82,547.61) per year. With the use of ESP, this cost could be reduced by as much as 40% down to 91,630 DM (\$49,530) per year. This amounts to an annual savings of 61,082 DM (\$33,017.45).

Another major cost associated with wastewater treatment is the disposal of sludge after anaerobic digestion. Figure 7- shows the effect of ESP treatment on sludge produced per kilogram of treated COD. Prior to ESP treatment, the approximate sludge mass produced was 0.7 kilograms per each kilogram of COD (kg/kg_{COD}) treated. After ESP treatment was initiated, sludge mass was reduced by about 30% to 0.5 kg sludge/kg_{COD}.

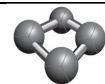
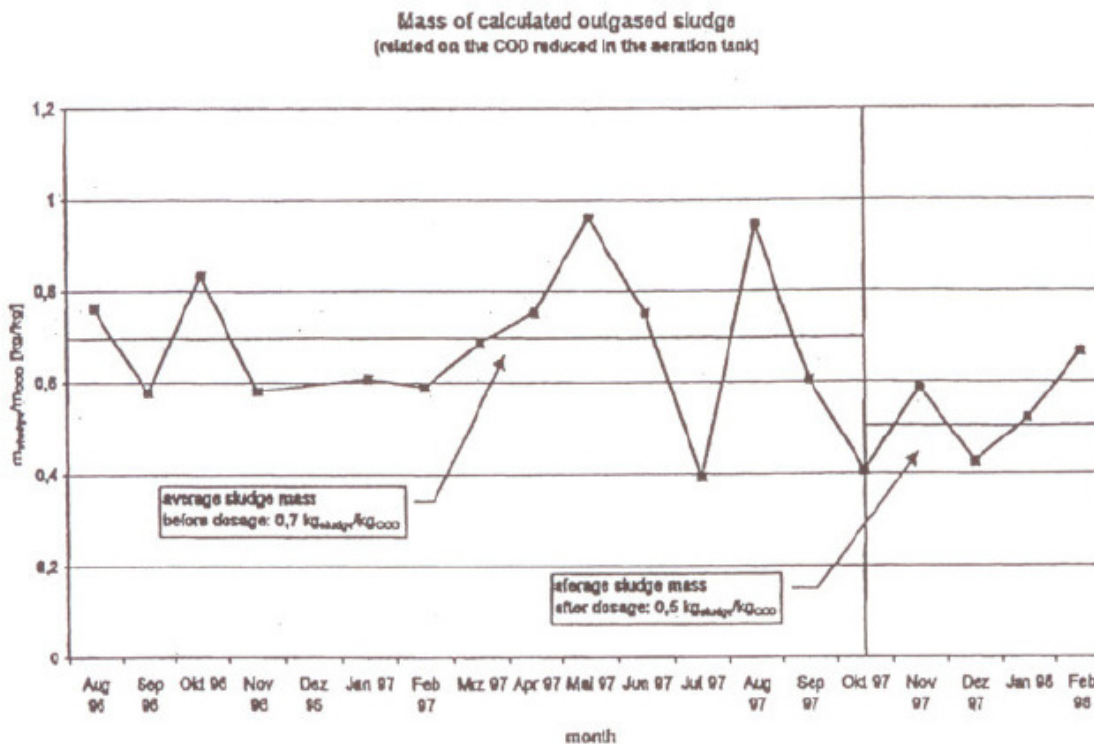


FIGURE 7



It is likely that three factors contribute to this very significant reduction in the amount of sludge produced per kilogram of COD removed:

- AB wastewater enters the Primary Settling Tank; a greater portion of it is solubilized by ESP treatment, reducing the load to the Anaerobic Digesters. This possibility is supported by the observation that after ESP treatment began, the amount of COD pumped from the Primary Settling Tank to the Aeration Tank increased.
- The amount of Biomass (activated sludge) pumped from the Aeration Tank back to the Primary Settling Tank: was most likely reduced, further reducing the total amount of sludge pumped to the Aerobic Digesters. The reduction in biomass within the Aeration Tank is the result of activated sludge biomass being forced into a state of endogenous respiration where cellular storage materials are consumed as a result of very high metabolic activity due to the greater availability of oxygen. The depletion of these energy stores is analogous to weight loss in people as a result of aerobic exercise.
- Some data suggest that the process of anaerobic digestion may have been more efficient with ESP treatment. This possibility is suggested by the fact that methane production remained virtually constant even though it is highly probable that less sludge was pumped to the Anaerobic Digesters, as explained above. This could occur only if a smaller amount of sludge was being more efficiently converted to larger amounts of methane as a result of the ESP treatment. Additionally, methane production did not appear to proportionally decline when only one instead of two anaerobic digesters was in use during a portion of the ESP evaluation interval.



CONCLUSIONS

The results of the ESP study performed at Westerholt, Germany demonstrates that ESP treatment can significantly improve the overall efficiency of municipal wastewater treatment. Specifically, ESP treatment had a positive impact on wastewater treatment at the Westerholt plant in the following ways:

- ESP converted a greater portion of influent organic solids to a form which could be more readily treated by the aerobic activated sludge process.
- ESP increased the availability of oxygen in the Aeration Tank so that less aeration was - required to degrade soluble wastewater components. The amount of aeration required to degrade COD was reduced by as much as 30%.
- As a result of the reduced need for aeration to degrade organic wastes (COD), the energy required to operate aeration compressors was reduced by as much as 40%. Based on a local energy cost of 0.18 DM/kWh, the use of ESP would result in an annual savings of 61,000 DM (\$33,000) for compressor power, alone.
- ESP treatment resulted in a 30% reduction in the amount of sludge produced per kilogram of COD removed by the wastewater treatment process. This reduction is most likely due to a combination of factors including a reduction in the amount of sludge that anaerobic digesters received as well as a more efficient conversion of organic solids to methane gas.

