CWIP

Initial Environmental Review of NWC Sewage Treatment Facilities in Ocho Rios

ARD

Coastal Water Quality Improvement Project

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Initial Environmental Review of NWC Sewage Treatment Facilities in Ocho Rios

January 2001

Prepared for the:

Government of Jamaica's
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And the

United States Agency for International Development

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ABBREVIATIONS

ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
C	Degree Centigrade
COD	Chemical Oxygen Demand
COD-f	COD of the filtered sample
COD-m	COD of the completely mixed sample
CWIP	Coastal Water Quality Improvement Project
d	Day
EMS	Environmental Management Systems
FTU	Formazine Turbidity Units
GOJ	Government of Jamaica
h	Hour
HRT	Hydraulic Residence Time
InWaSia	In Waste water Systems interactive (iterative) approach
ISO	International Organisation for Standardisation
kg	Kilogram
L	Litre
m^2	Square Metre
m^3	Cubic Metre
MLSS	Mixed Liquor Suspended Solids (Parameter to describe biomass of activated sludge)
mS	Milli Siemens
mV	Milli Volt
N	Nitrogen
NEPA	National Environment and Planning Agency
NH_4-N	Ammonia Nitrogen
NO_2-N	Nitrite Nitrogen
NO_3-N	Nitrate Nitrogen
NRCA	Natural Resources Conservation Authority
NWC	National Water Commission
o-P	Ortho-Phosphate
P	Phosphorous
PE	Population Equivalent
PS	Pump Sump/Sewage Relift Station
SRT	Solids Retention Time
STP	Sewage Treatment Plant
SVI	Sludge Volume Index
t	Tons (Metric)
TN	Total Nitrogen
TP	Total Phosphorous
UASB	Upflow Anaerobic Sludge Blanket Reactor
WC	Water Column

NOMENCLATURE

On-line is the continuous and interactive measuring by sensors of operating conditions which provides information that facilitates immediate responses to changes

Environmental aspects are elements or part of an activity or product or service that interacts with or has some relation to the environment

Environmental impact is a change in the environment which is adverse or beneficial, wholly or partially, resulting from an organisation's activity, product or service.

Clause 4.3.1 of ISO 14001 requires on organisation establishes and maintains procedures to identify aspects which it can control, over which it expects to have an influence and determine those aspects which have or can have significant impacts on the environment. The clause also requires that aspects are considered in setting objectives and that information is kept up to date.

The **redox potential** is given by the formula below. The normal potential (Eo) has different value for each oxidation reduction reaction. n is the number of participating ions. Ox/Red is the concentration ratio of oxidising and reducing ions.

$$\textbf{Redox Potential (E)} = E_o + {}^{0,66}/_{n} \times \log ({}^{Ox}/_{Red})$$

The redox potential will increase when the concentration of oxidised ions increases in relation to the concentration of reduced ions. Under anaerobic conditions the redox potential may drop to –300 mV or more.

The redox potential can be used to follow redox reactions like denitrification, sulphate reduction, sulphide oxidation, etc.

Free board is the difference between the water line and the maximum possible water level in a reservoir.

1 BACKGROUND TO THE PROJECT

The National Environment and Planning Agency / Natural Resources Conservation Authority (NEPA/NRCA) through the Coastal Water Quality Improvement Project (CWIP) Contract Result 3 (CR 3) - Environmental Practices of Industries and Commercial Establishments Improved has been working to promote the implementation of EMS in support of the development of a national agenda that recognises the role of government, private sector and non-government organisations in environmental management.

Environmental Management Systems (EMS), based on the ISO 14000 series, are being increasingly accepted, adopted, and implemented by industry, the services sector, utilities, local government, and commercial enterprises. It is generally agreed that an EMS is a powerful tool for achieving environmental protection and improved business operation. In this regard, the EMS policy and strategy is viewed by the GOJ/NEPA/NRCA as a step along the sustainable development path which will assist the country's ability to 'grow capital' – the natural, economic and human.

Drivers

Globally, the EMS approach is being rapidly adopted as a tool to achieve improvements in internal efficiencies within operations thereby helping to reduce costs and achieve a competitive advantage. Bankers and insurance companies are requiring assessments of environment risks before funding projects. Governments are moving towards green procurement and regulators are using EMS adoption as a mechanism for regulatory flexibility. The drivers for EMS implementation internationally are as follows:

- Global competition
- Market pressures
- Improving efficiencies
- Public image/Stakeholder demands
- Enhanced competitive advantage
- Environmental protection
- Financial requirements

The guiding principles of the policy and strategy embrace a number of philosophies. These include sustainable growth, implementation of EMS as a fundamental tool to help achieve sustainable development, voluntary implementation of EMS and the full participation of and provision of information to all citizens of Jamaica re the quality of the environment.
The GOJ has taken the stance that it must lead from the front with regards to the promotion of the EMS policy and strategy. In regard, ***Goal 1 Strategy 1.5 Build capacity to plan, implement monitor and evaluate sustainable communities using an EMS approach.***

GOAL 1: To establish the framework within which Environmental Management Systems will be adopted across all sectors of society.

One of the proposed actions is to 'Implement EMS in a regional waste water division of the NWC'. The leadership of the NWC endorse this approach and have requested that CWIP provide the technical assistance to develop and implement an environmental management system for three of its sewage treatment facilities, Negril; Montego Bay; and Ocho Rios.

2 BACKGROUND ON THE CONSULTANTS

CWIP contracted two short-term experts to provide the technical assistance to conduct the initial environmental review and to provide an overview of the performance of the Ocho Rios Systems. A brief introduction to the two consultants is found below.

- Robert Wynter is a Chemical Engineer and Management Consultant with wide experience in environmental audits and EMS'.

- Johan Verink is an Environmental Engineer with commitment to the development, adaptation, transfer and implementation of know-how in the wastewater treatment sector.

This document is intended to present a detailed description and interpretation of the investigations at the Ocho Rios sewage treatment facility.

3 PURPOSE OF THE STUDY

The purposes of this study are to:

1. Conduct an initial environment review of the NWC Ocho Rios sewage treatment facilities.

2. Provide a performance review of the facilities.

3. Prepare a report on the findings of the initial environmental review to provide data to support the implementation of an EMS.

Tasks

The proposed tasks for the consultant are as follows:

1. Determine the flow and influent characteristics of the wastewater going to the sewage treatment facilities using proportional sampling and conductivity measurements;

2. Determine plant performance and environmental impact using on-line monitoring and sampling technology.

3. Analyse treatment process performance including:

   - Load distribution
   - Load distribution
   - Daily variations in oxygen concentration and suspended matter in effluent
   - Effluent quality

4. Review and analyse NWC records describing concentrations of water quality parameters found in the final effluent at the Ocho Rios plant since it commenced operation.

5. Identify the significant environmental aspects.

6. Liase with NWC's operational staff at the Ocho Rios facilities re the provision of existing information to be incorporated into the report.

7. Prepare the initial environment review reports.

Organisation of the Report

Investigations in Ocho Rios involved on-line monitoring of the influent at the main pumping station 3 and additional monitoring at the ponds.

This report firstly outlines the findings of the influent characteristics followed by am assessment of the treatment plant performance.

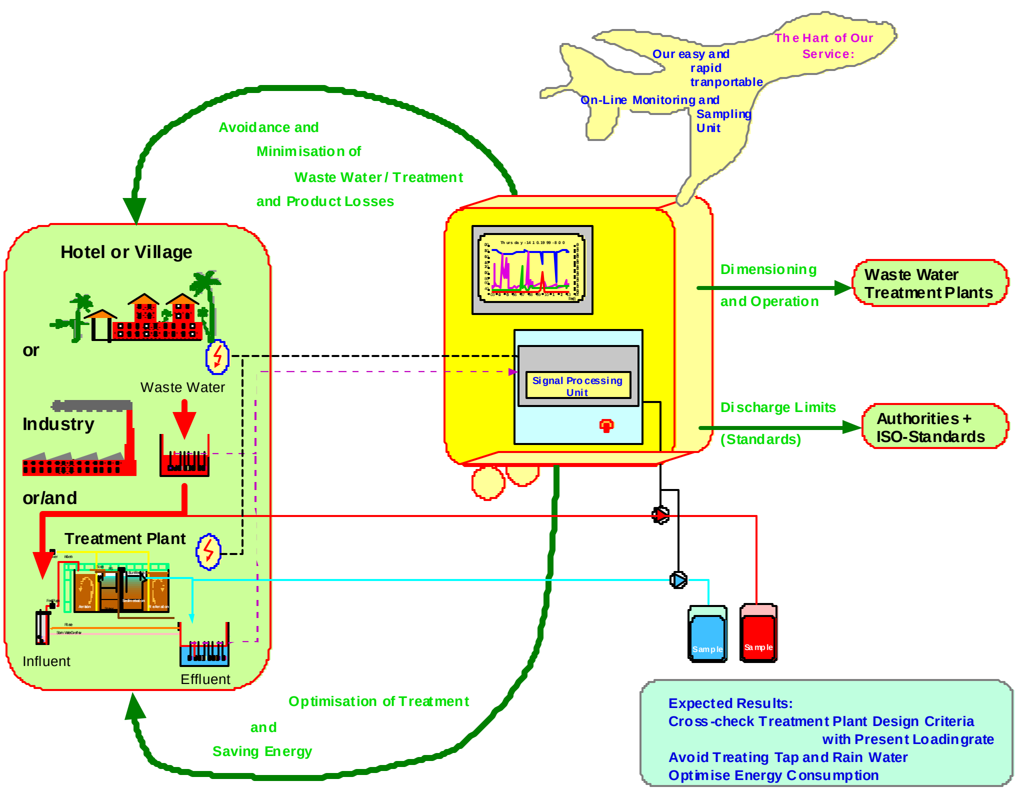
4 APPROACH

On-line monitoring and sampling technology was at the heart of the approach and was used to provide immediate and valuable information on the operations. The system sampled both time and volume proportionally, and monitored:

- Waste water characteristics
- Flow
- Electricity consumption

An overview of the concept is shown in Fig. 1

Fig. 1 On-Line Monitoring and Sampling Technology Concept



The benefits of the approach are: avoidance and minimisation of environmental impacts; reduction of product losses; optimisation of wastewater treatment; energy savings; data for treatment plant design and/or upgrade; data for environmental compliance programmes and/or upgrade and data for environmental compliance programmes.

Work Programme

For the Ocho Rios Sewage Treatment Facility the following approach was used:

- Preliminary visit to the plant for familiarisation and an initial review of documentation

- Transferred, installed and tested the equipment at the contact tank

- Commenced on-line measurements and sampling
- Monitoring and sampling at Ocho Rios sewage treatment plant from December 22 - 30, 2000

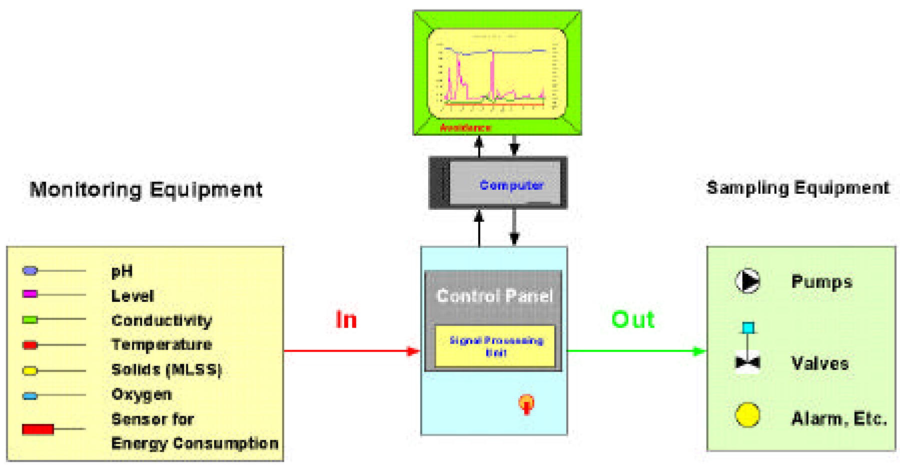
5 FIELD INVESTIGATIONS

A computer controlled unit was used for on-line data monitoring and sampling. The features of the equipment enable one to take different types of samples: grab, continuous, time and volume proportional samples.

The unit was equipped with sensors to monitor the following parameters on line:

- pH
- Temperature
- Conductivity
- Redox potential
- Oxygen
- Solids (Sludge)
- Level (Pressure, height or flow)
- Power Consumption

Fig. 2 Overview of the Monitoring and Control Unit



5.1 Data Collection

The following sections of the report outline our approach to measure flow and the various sampling techniques.

5.1.1 Flow

At the Screen, a flow monitoring device was installed. The device was calibrated through backing up water in the inflow chamber. This value, 329 m^3/h was very similar to the one read at the flow meter of the treatment plant.

5.1.2 Sampling (Volume Proportional)

<u>Influent</u>

A hose with a screen was positioned in the inflow to the contact tank at around 30 cm below the water level. Every time the inflow to the treatment plant started, waste water was pumped into containers of the automatic sampler. In this way, the best possible sampling (volume proportional sampling of the sewage) was ensured.

Effluent

For the sampling of the treatment plant effluent time-proportional samples were taken of the outflow from the sedimentation tank (See Fig. 5).

5.1.3 Sampling (Grab)

Grab samples were taken from the activated sludge in the oxidation ditch and the return sludge to determine the sludge volume and the sludge content.

5.1.4 Chemical Sample Analysis

In situ analyses of settleable solids, pH, redox, conductivity and suspended solids were done. The samples for chemical analysis COD, ammonia, nitrate, total nitrogen, ortho-phosphate and total phosphate were preserved for analysis. Faecal Coliforms was carried out in laboratories. BOD measurements were not carried out since the COD of the mixed sample was already extremely low, no settleable solids were found in the regular samples and the ammonia concentration was also close to zero.

5.2 Data Elaboration

Data collection, elaboration and presentation have been carried out by the use of the following software packages:

- DASYLab, Company WAL, Oldenburg, Germany
- XACT (similar to Excel), Company SciLab, Hamburg, Germany
- Microsoft Word 97
- Microsoft Excel 97

6 OVERVIEW OF THE OCHO RIOS SEWAGE TREATMENT PLANT

Location

Several pumping stations feed to the main pumping station (Fig. 3), which conveys the waste water to the automatic screen at the treatment facility

Type

Two parallel operated oxidation ditches, followed by a sedimentation tank (Fig. 4). The two systems cannot be completely operated separately. Effluent from the oxidation ditches joins, which could be separated with minor efforts, however, the return sludge from the sedimentation tank joins in the return sludge pump sump where there is no wall to separate the return sludge to both oxidation ditches.

Surplus sludge is thickened and dried on drying beds.

Disposal

Dried sludge is stored at the treatment plant until disposal/use for land application is available.

The treatment plant effluent flows via a deep sea outlet with diffusers into the nearby sea, west of Ocho Rios

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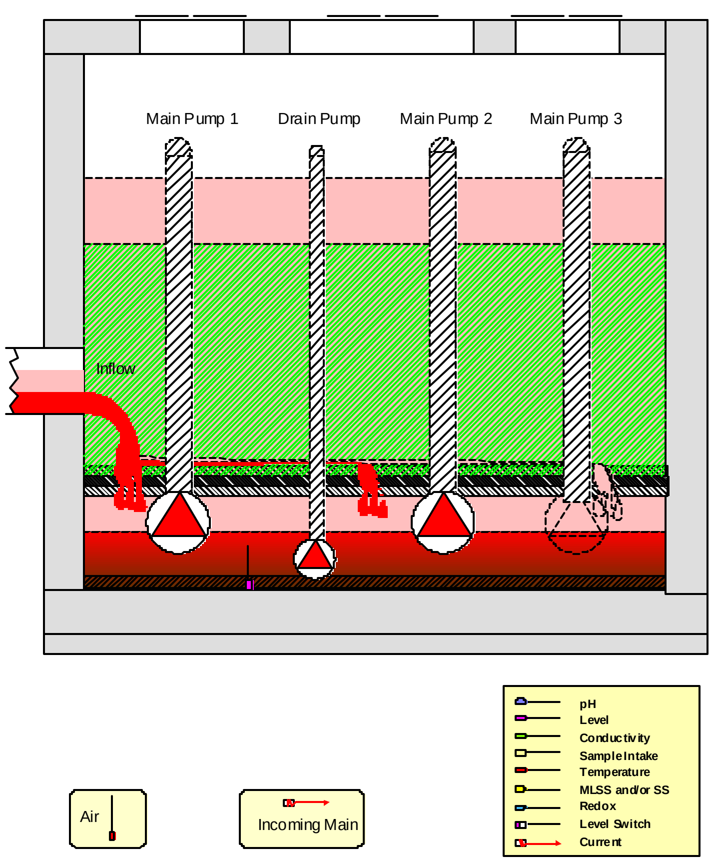
Fig. 3 Schematic Display of Pump Sump Feeding to the Automatic Screen of Treatment Plant



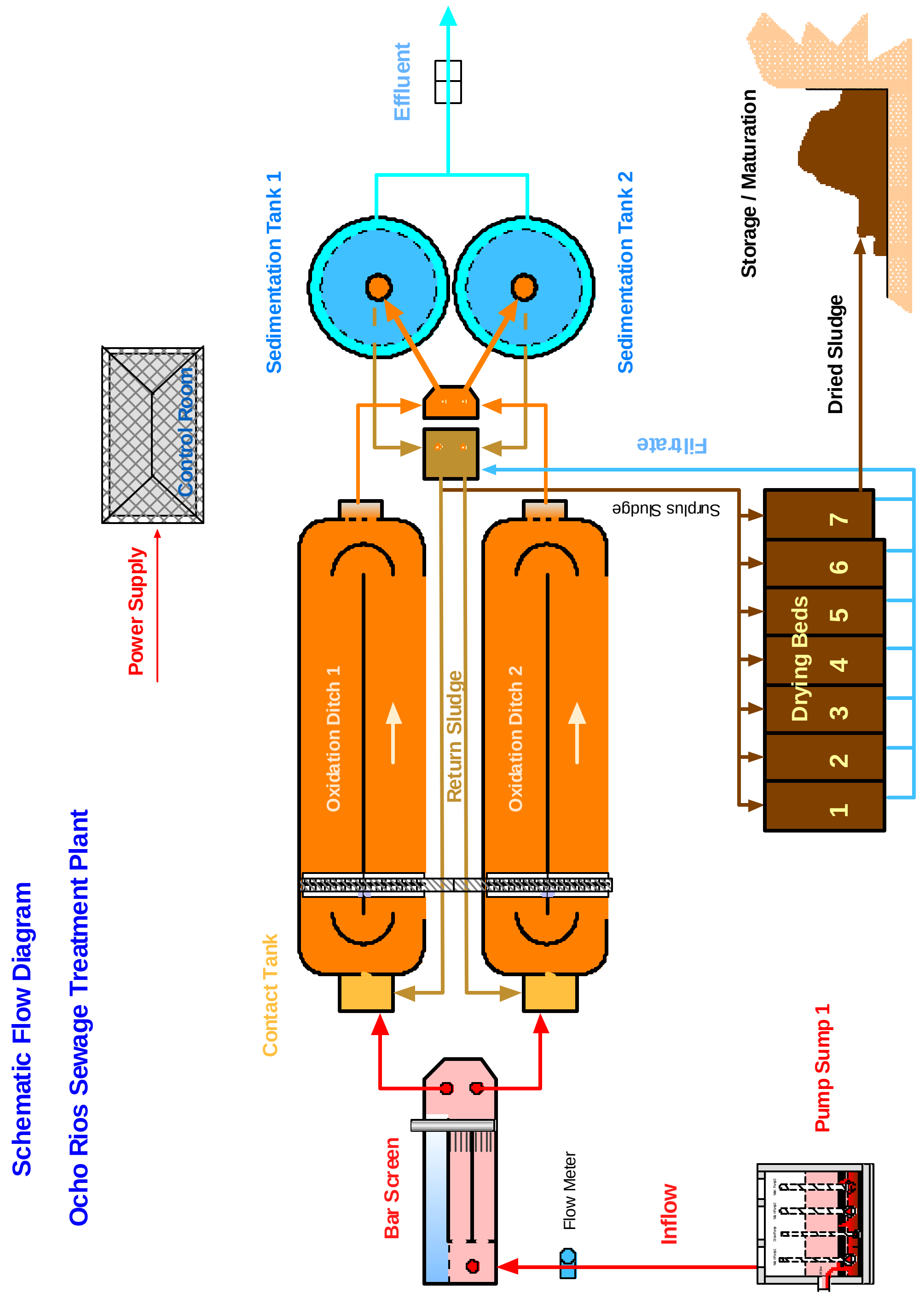


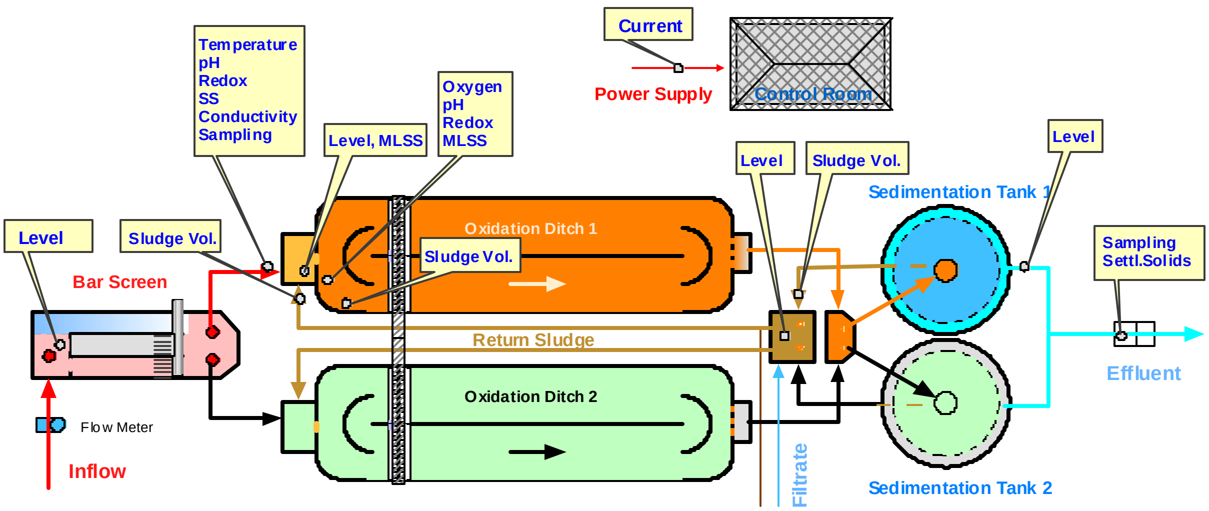
Fig. 4 Schematic Overview of Ocho Rios Waste Water Treatment Plant

The oxidation ditches each have a volume of 5104 m^3. The free board between 500 and 800 mm. The sedimentation tanks each have a volume of 1846 m^3.

The contact tank has an effective area (water surface) of around 27,56 m^2 and an effective volume between 95,6 and 87,3 m^3. This volume varies because the water level in the oxidation ditch varies with the adjustments of the overflow weir to adjust the oxygen supply to the activated sludge.

The return sludge tank has an effective area of approximately 18,8 m^2. The plant has 7 sludge drying beds. They occupy an effective area of around 1600 m^2. Fig. 5 displays the monitoring and sampling points for different parameters.

Fig. 5 On-Line Monitoring and Sampling Points



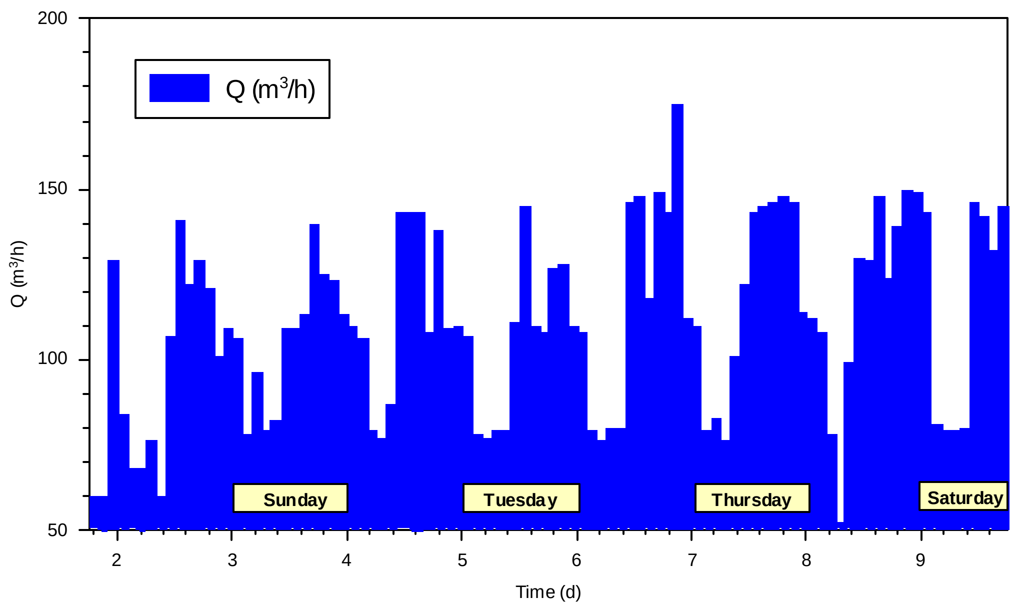
7 INFLUENT CHARACTERISTICS

The following section of the report outlines the findings from the monitoring and measurements at the automatic screen near the contact tank of the oxidation ditch.

7.1 Flow

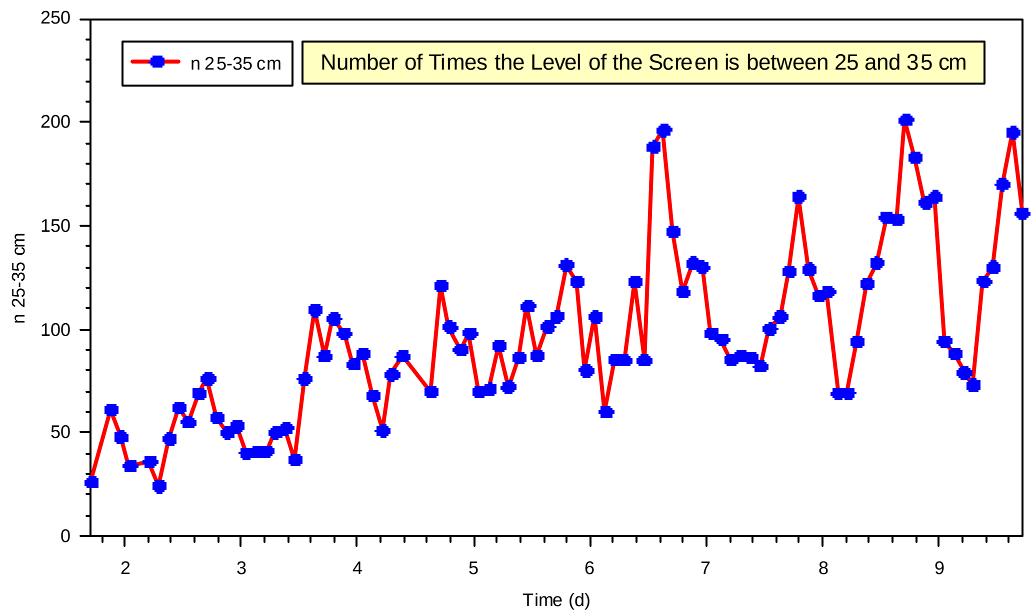
The graphical determination of the 2-h average flow into the contact tank is shown in Fig. 6 . The average flow is 2600 m^3/d with a minimum of 52 m^3/h and a maximum of 175 m^3/h. The normal minimum and maximum values are between 80 and 150 m^3/h. The peak flow is during the day, minimum flows at night.

Fig. 6 Daily Inflow Variations to the Treatment Plant



The pattern seen during the flow out of the chamber in front of the screen is retarded by the reduction of the cross-section of the bars, but also by the screenings attached to the bars. 0shows the number of times the level is between 25 and 35 cm in front of the screen.

Fig. 7 Level in Front of the Screen



At high flow the level in front of the screen ranges more frequent between 25 and 35 cm. This means that the water is not readily flowing out of the influent chamber in front of the screen, in other words, there is a clogging of the screen bars near the bottom of the screen. At night time, when the time between two feedings increase, there is more time for the water to trickle out. During the week of investigations the number of times the level is between 25 and 35 cm continually increased. This can be observed for the peak and the minimum values. Observations at the screen during low flow showed an accumulation of screenings at the backside near the bottom. Such matter could, when entering the RS pumps, lead to problems. This indicates that more frequent manual cleaning of the screen is required.

7.2 Conductivity

The following two figures show the conductivity over a short period (24 hours) and over the longer sampling period. The values are predominantly just below 1 mS/cm, an expected range for sewage. The occasional peaks were up to around 5 mS/cm and associated with batch loads of salty water (brownish coloured) which, may be from water treatment plants or, less probable, a contribution from a sump infrequently emptied, where salt water has infiltrated. Fig. 8 shows that the salt peak coincides with an increase of pH.

Fig. 8 Conductivity and pH during a Short Period of Time

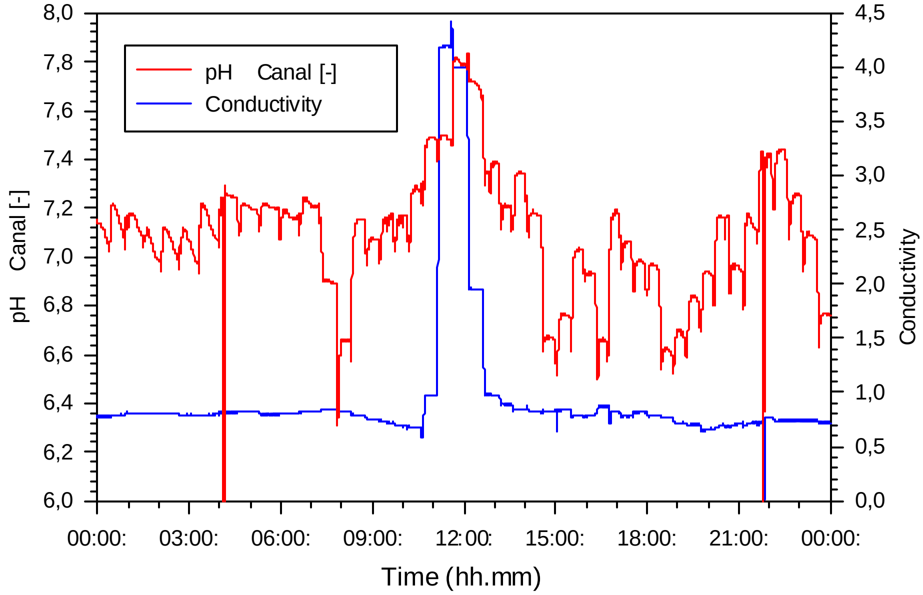
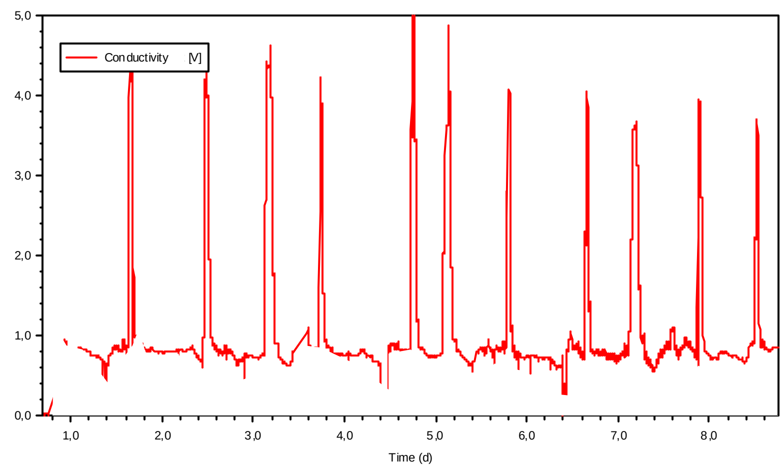


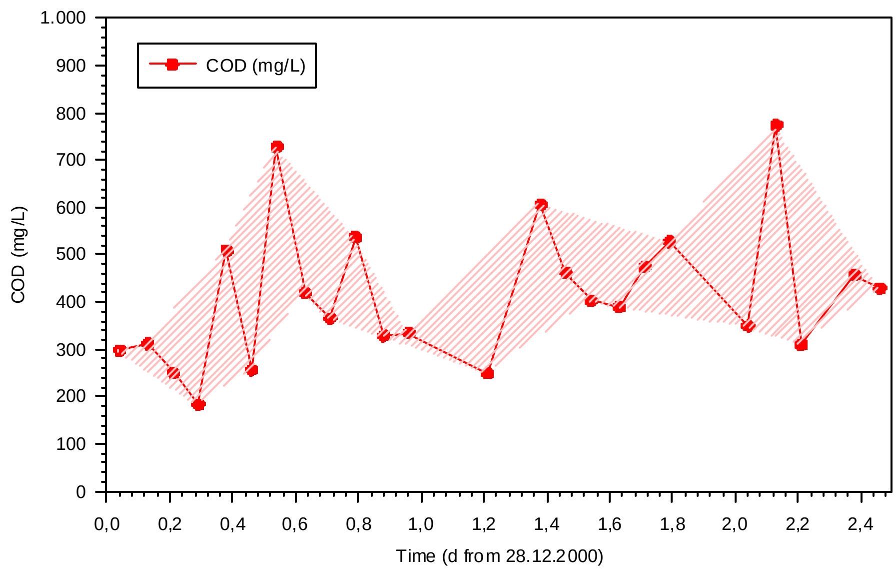
Fig. 9 Conductivity of the Incoming Sewage over the Sampling Period



7.3 COD, N and P

The daily variations of the Chemical Oxygen Demand (COD) of the wastewater on 28, 29 and 30.12.00 were sometimes relatively strong for sewage in Jamaica (Fig. 10). Values reached 600 to 700 mg/L. At night the values dropped to 200 - 300 mg/L.

Fig. 10 Daily Variations of COD in Influent



The COD of day composite samples (see Tab. 1.) varies between 110 and 460 mg/L. The low COD was on 25.12.00, a public holiday. The Nitrate concentration in the influent is low as to be expected. The wastewater contains significant amount of phosphorous, expressed as total phosphorous, whose concentration varies between 7,6 and 12,2 mg/L.

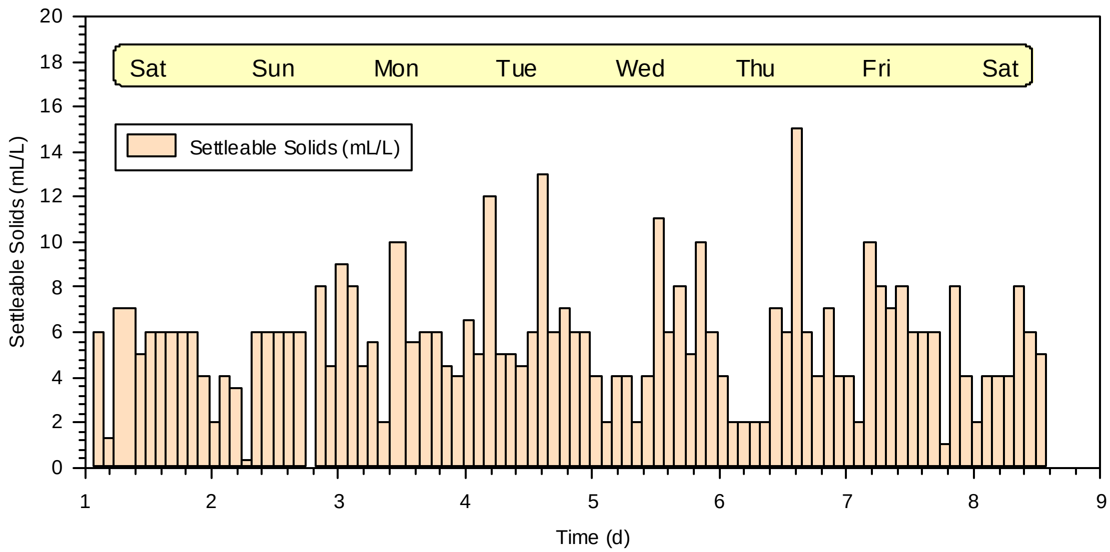
Tab. 1. COD of Composite Influent Samples

	COD (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NO_3-N (mg/L)	TP (mg/L)
23.12	214	27,5	21,2		12,2
24.12	181	28,7	23,5		9,5
25.12	110	29,5	17,1		8,6
26.12	300	30,2	17,2	0,4	8,6
27.12	300	> 12	18,4		7,6
28.12	345		15,9		
29.12	459		12,2		
30.12	400				

7.4 Settleable Solids

The settleable solids, not unusually, ranged widely from 1-16 mL/L. The pattern in the influent shows most values around 6 mL/L which suggests a rather regular discharge of settleable matter to the sewer.

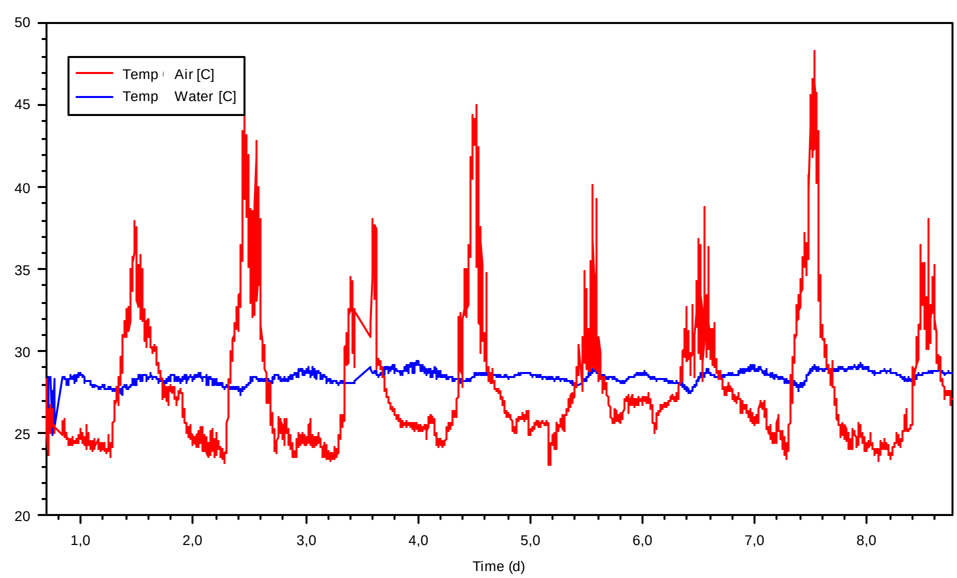
Fig. 11 Settleable solids of 2-h Composite Influent Samples



7.5 Temperature

The wastewater temperature, as shown in the figure below, varies slightly around 28 C.

Fig. 12 Temperature of Influent and Air

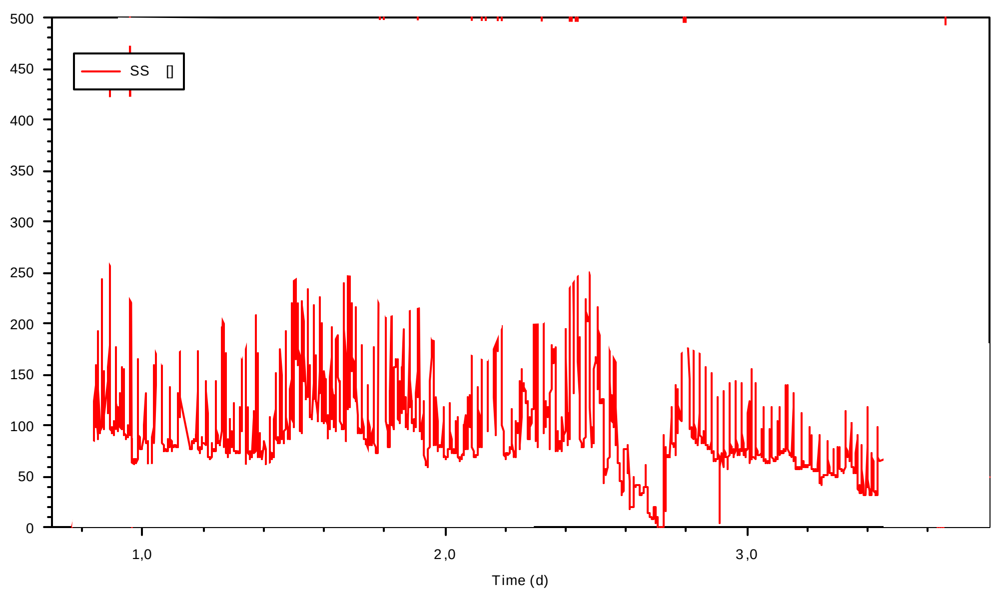


The air temperature, however, varied from around 23 and 37 C with peaks during sunshine of over 40 C (Sensor was not subjected to direct sunlight).

7.6 Suspended Solids

On-line measurement of suspended solids varies slightly and less than expected (Fig. 13). The FTU reaches very low values during day 2 (25.12.00).

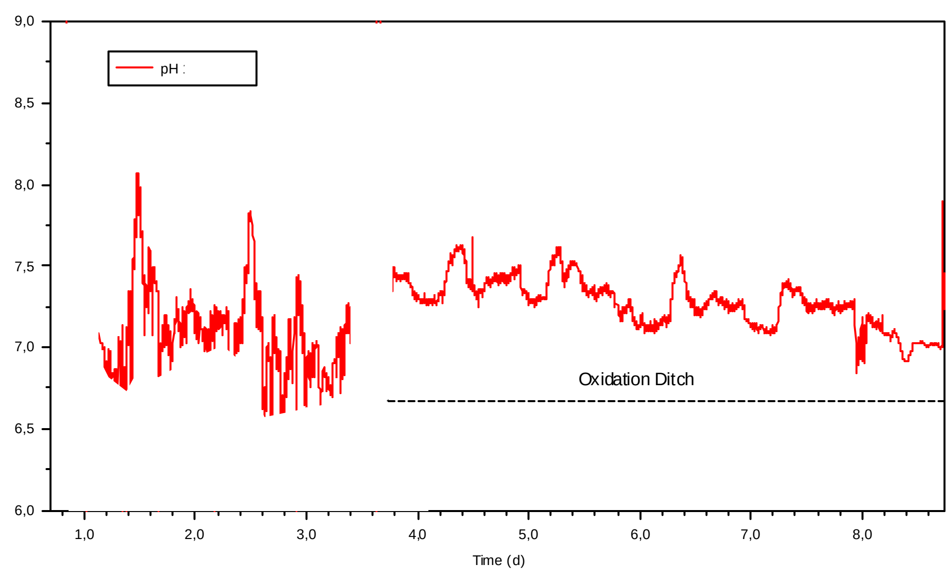
Fig. 13 SS (FTU) in Influent



7.7 pH

The pH is shown in Fig. 14 . The variations in the inflow are between 6,5 and 8. Predominantly the pH is around 7. In the oxidation ditch the pH shows a slight general falling tendency.

Fig. 14 pH in Influent and in Oxidation Ditch

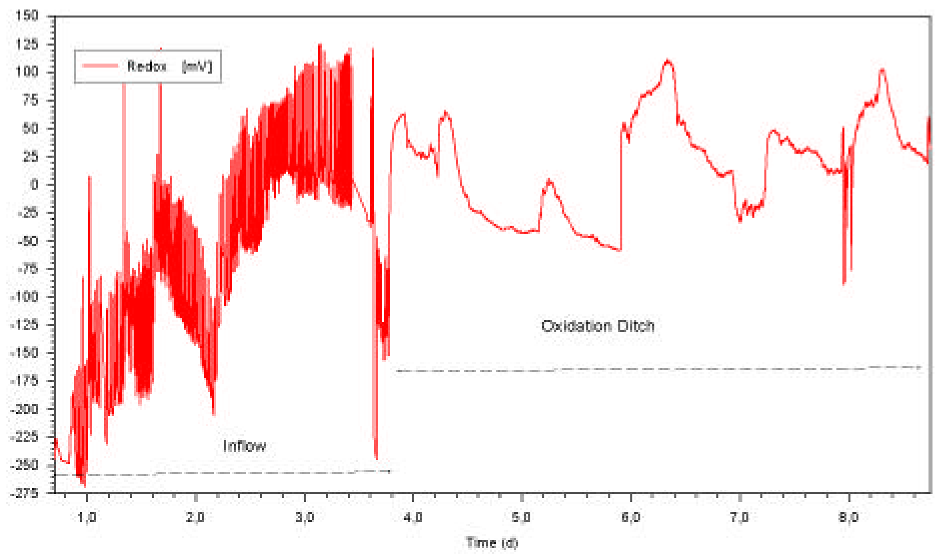


In general one can see, that the pH values are a bit higher during the day than during the night, however the differences may not have a significant impact on the biological process. An increase could mean that less nitrate has been formed or more nitrate has been used, thus providing information about the denitrification process. The increase during the day could be also caused by an increased pH of the incoming wastewater which can be observed during the monitoring of the inflow.

7.8 Redox

In the nomenclature a brief description is given of the redox potential. Fig. 15 shows an increase from a negative redox potential to a positive one, indicating that the pollution load decreased over the period. This coincides with the low COD of the composite sample on 25.12.00. Since the redox can provide valuable information about the denitrification in the oxidation ditch, the probe was placed there. The typical changes of the redox potential, due to denitrification, were not observed. During the night the redox potential increases, indicating that the conditions for denitrification become less favourable.

Fig. 15 Redox Potential in Influent and Oxidation Ditch



7.9 Hydrogen-Sulphide

The incoming wastewater had normally the typical sewage smell. However observations during the sampling period revealed that there were on few occasions, particularly when wastewater entered the screen and contact tank, an intensive smell of rotting eggs. It has to be noted, that different people describe the smell differently.

7.10 Summary of Major Findings

The major findings of the investigation of the influent are summarised below:

- The flow rate is normally between 80 - 150 m^3/h, with an average of 111 m^3/h or around 2700 m^3/d a significant environmental aspect

- The Phosphorous concentrations in the inflow indicate for this type of treatment process a significant environmental aspect

- The screen requires more frequent manual cleaning.
- COD ranged from below 200 to 800 mg/L. This is usual for sewage.
- Odour from the inflow to the plant represents sometimes a significant environmental aspect
- The sump, from where the waste water is pumped into the plant, cannot be routinely emptied completely

8 TREATMENT PLANT PERFORMANCE

The following section of the report outlines the findings from the monitoring and measurements of the treatment plant performance in terms of effluent quality, sludge characteristics and energy consumption.

8.1 COD and Nutrients

The Effluent COD and nutrient concentrations of the treatment plant are presented in Tab. 2. The effluent quality in terms of COD and ammonia is excellent. Improvements with respect to nitrate levels can be obtained through improved denitrification (control of oxygen levels in the oxidation ditch). Whether biological P-removal can be enhanced through process optimisation is not completely certain at this time. In order to reduce the P levels in the effluent, simultaneous P-precipitation is an option.

Tab. 2. Effluent Characteristics

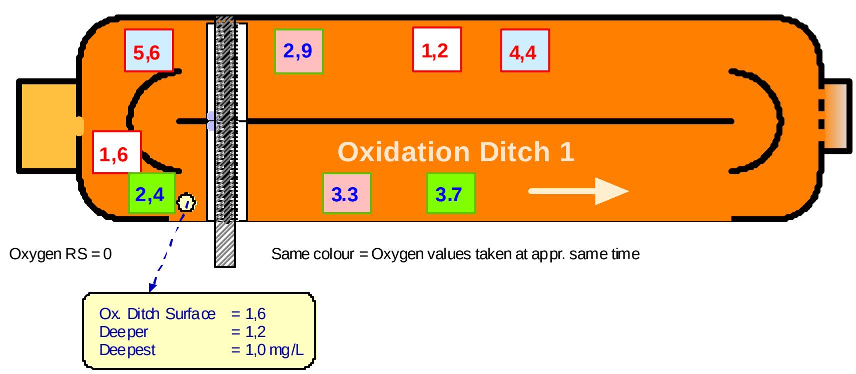
	COD (mg/L)	TN (mg/L)	NH_4-N (mg/L)	NO_3-N (mg/L)	o-P (mg/L)	TP (mg/L)
23-25.12	< 25	16,2	< 1	13,2	1,2	5,7
26-29.12	< 25	19,0	< 1	13,5	1,4	5,8
12.01	55		< 1	10,6	1,3	
15.01			< 1	12,0		
20.01				13,6		

Denitrification will also lead to significant energy savings and probably also to an improvement in sludge characteristics (SVI).

8.2 Oxygen

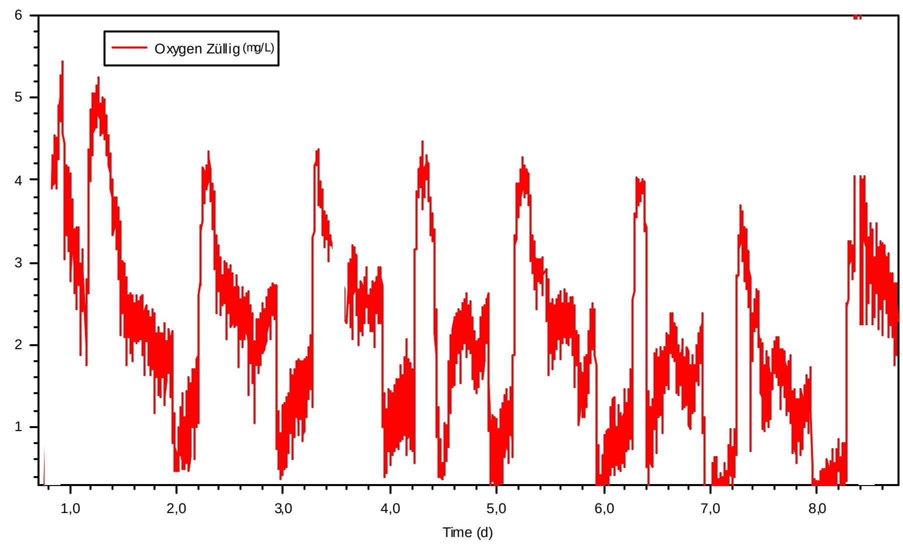
One oxidation ditch and one sedimentation tank were in operation during the week of the investigations. First oxygen measurements revealed oxygen presence over the entire length and depth of the oxidation ditch. 0 shows paired oxygen measurements and confirms the findings over the length of the ditch.

Fig. 16 Paired Oxygen Measurements in the Oxidation Ditch



The oxygen profile in the oxidation ditch is measured on-line next to inlet of the contact tank. The results are shown in **Fig. 17**. It is interesting to see that the high oxygen concentrations up to 5 mg/L no longer appeared after the second day. The oxygen concentration varies depending on return sludge flow and the load of the influent. An interesting observation took place during the week, which supports the case for denitrification. Every day at around 10:30 p.m. one aerator was switched off. At the same time the level in the oxidation ditch was increased to near maximum while the oxygen concentration decreased to around zero, creating the conditions for denitrification.

Fig. 17 Oxygen Profile in the Oxidation Ditch

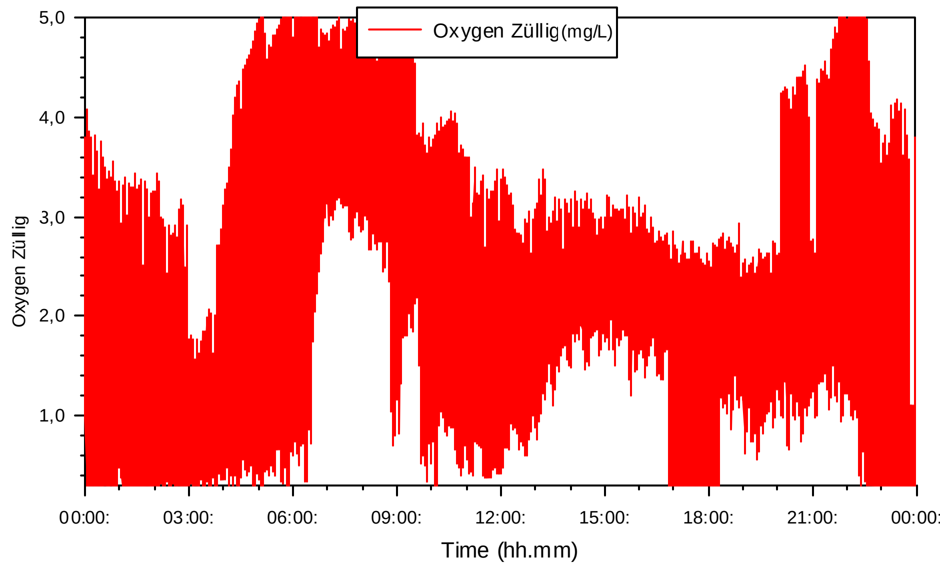


After this dip the oxygen concentration started to increase again and the conditions for denitrification reduce. More detailed investigations and adjustments are required to determine and operate at optimum operational conditions for denitrification. On-line monitoring of oxygen in the activated sludge, on-site chemical analysis, together with an automatic adjustment of the overflow weir is essential for process control and to induce denitrification. Careful thoughts are also required with respect to switching off aerators during night time, if at all at what time and how long. Intermittent aeration might have to be taken into consideration as well. Note that the investigations revealed a reduction of the flow occurs after midnight (see Fig. 6).

The aeration at the treatment plant is frequently controlled through the power uptake of the aerators. Since the load variations are significant during the day and over the week, this control process methodology requires improvement.

The oxygen profile (Fig. 18) shows significant potential for energy savings of 20% to over 50%. This can be achieved through on-line monitoring and proper control of the oxygen concentration.

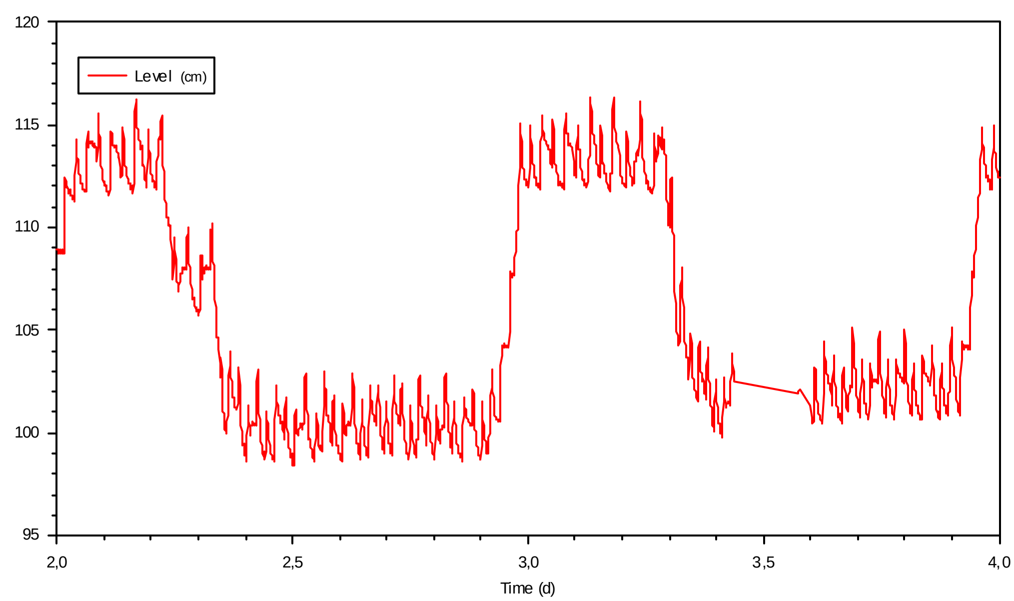
Fig. 18 Summarised Daily pattern of Oxygen Concentrations in the Oxidation Ditch



8.3 Level in Oxidation Ditch

Fig. 19 show the level in the oxidation ditch over 2 days. The level varies around 4 cm in height. This is due to the return sludge and the inflow being pumped batch-wise into the oxidation ditch. At around 10:30 pm the level in the oxidation ditch is increased by around 15 cm due to an adjustment of the overflow weir. At around 600 a.m. the level is reduced by approximately the same value.

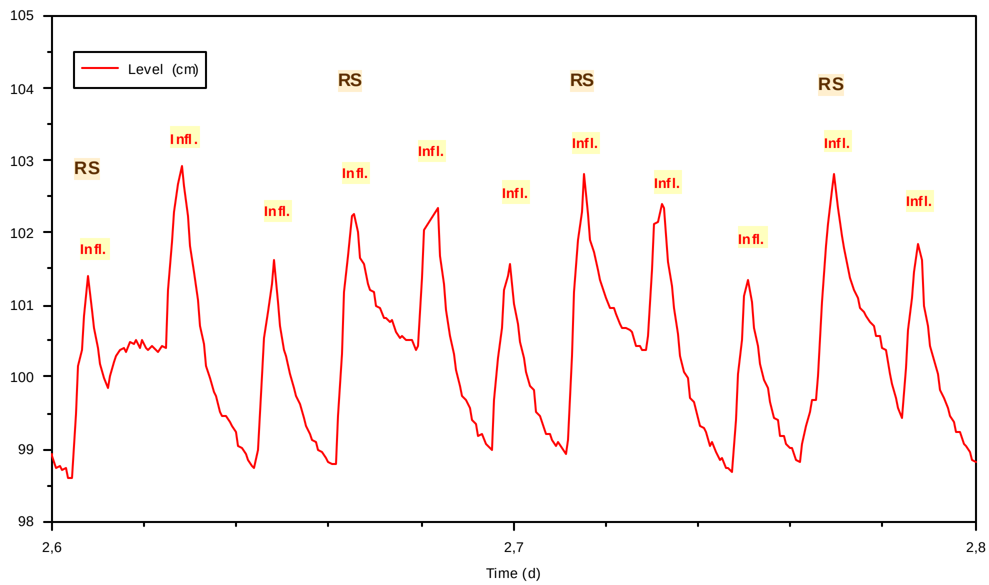
Fig. 19 Level in Oxidation Ditch



A detail of the above figure is shown in the figure below. This Fig. 20 shows that sludge is returned 4 times in around 5 hours while the inflow takes place around 11 times during the same period, thus describing that return sludge (bigger peak) and waste water inflow (smaller peaks) do not necessarily coincide, one of the different requirements for the proper operation of the contact tank. The measurement of settleable solids in the contact tank (sludge volume determination in 1000 mL cylinders) and on-line measurements with the solids sensor revealed strong variations in the sludge content, indicating that no proper mixing of return sludge and influent takes places all time in the contact tank.

Inflow and return sludge should jointly enter the contact tank to create the favourable conditions for better sludge characteristics (SVI).

Fig. 20 Short Period of Level Changes in Oxidation Ditch



The average residence time of sludge and wastewater in the contact tank is at present around 30 min, which is greater than the design value. However, when looking into detail of flow and mixing, this contact is could be unsatisfactory.

8.4 Outflow pattern of Sedimentation Tank

The figure below shows the outflow pattern of the sedimentation tank.

Fig. 21 Level Variations in the Outflow Canal of the Sedimentation Tank

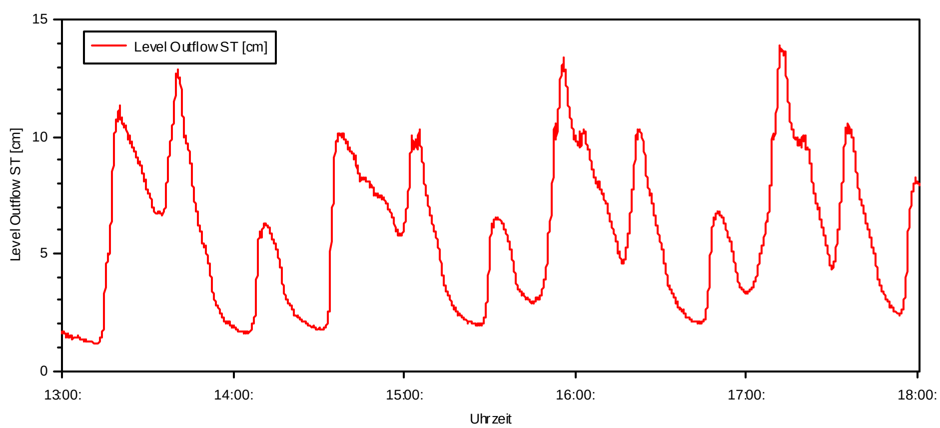


Fig. 21 show a similar pattern as the level in the oxidation ditch. The small peaks occur shortly after influent enters the oxidation ditch. Additionally there is the pattern of return sludge, which starts every hour and a half. During no inflow to the oxidation ditch there is hardly any outflow from the sedimentation tank. Here, one observation has to be mentioned. The overflow weir of the sedimentation tank in operation was not properly attached to the sedimentation tank wall so that effluent flows below the V-notched effluent weir.

The average overflow rate of the weir is less than 1 $m^3/(m.h)$. At this flow rates no suspended matters, other than from cleaning the surface of the sedimentation tank, has been observed leaving with the effluent.

8.5 Current

Current has been monitored at three incoming lines to the treatment plant. These signals on the three lines are different and cannot be explained by the power consumption of the aerators and small equipment of the treatment plant. Fig. 22 shows during the nighttime strong variations in current. Fig. 23 show this in more detail. This phenomenon was never observed during the day time.

The power consumption increases sharply in the morning at the point where the second aerator is started again. The power consumption more than doubles. After some time the increase stabilises between 100 and 120 A. Taking the oxygen concentration into consideration, there is still room for significant energy savings.

Fig. 22 Current

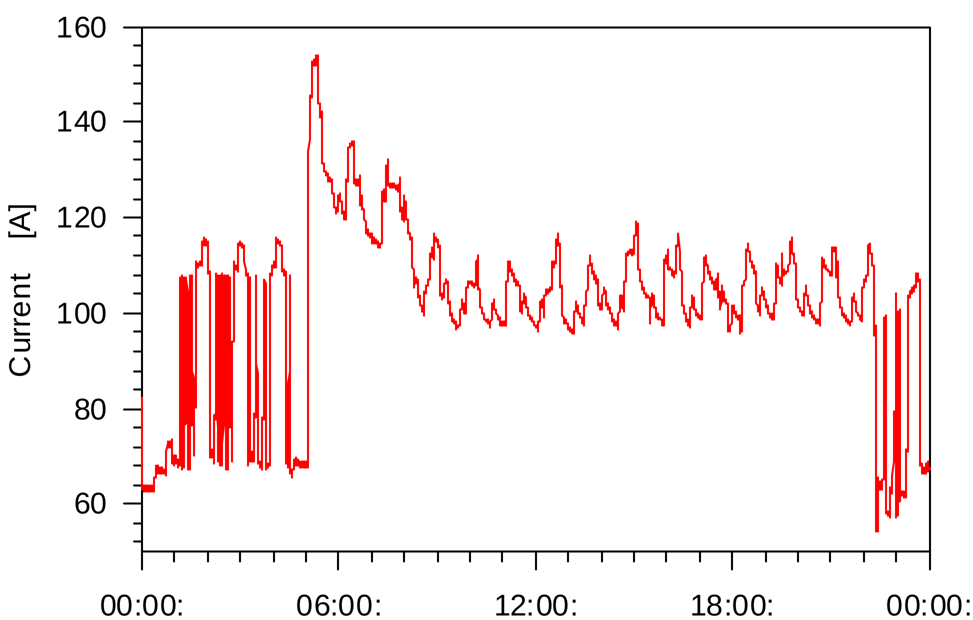
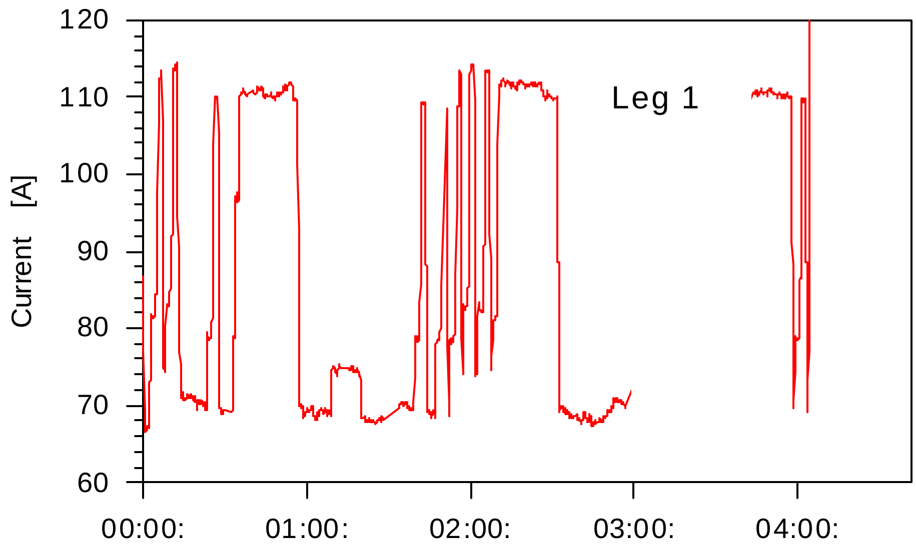


Fig. 23 Current Detail



The current drawn on the different legs of the power lines shows different pattern. Leg 3 behaves totally different, a behaviour which may require explanation.

Fig. 24 Current Monitoring on Different Legs

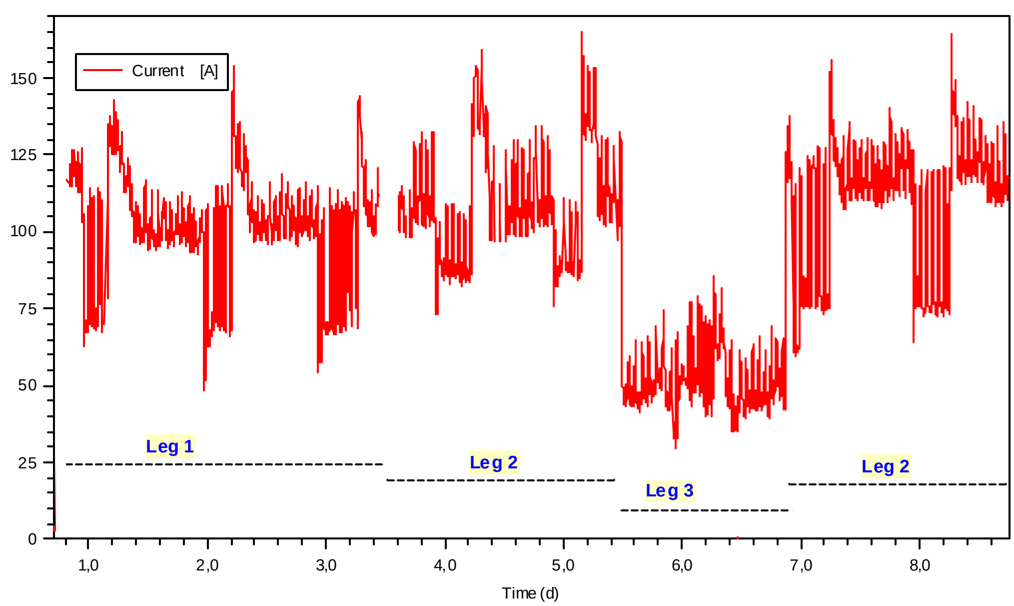
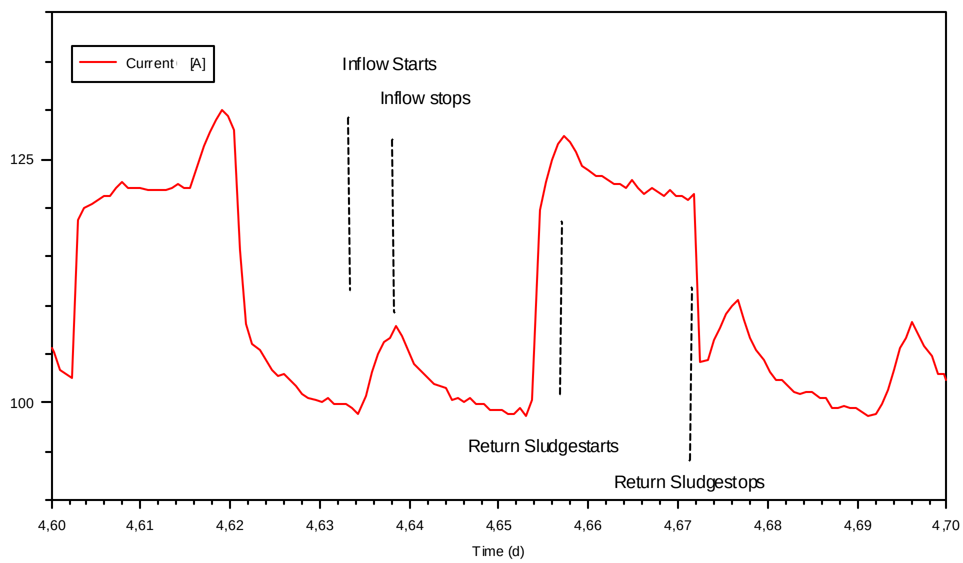


Fig. 25 Current Detail in Relation to Inflow and RS



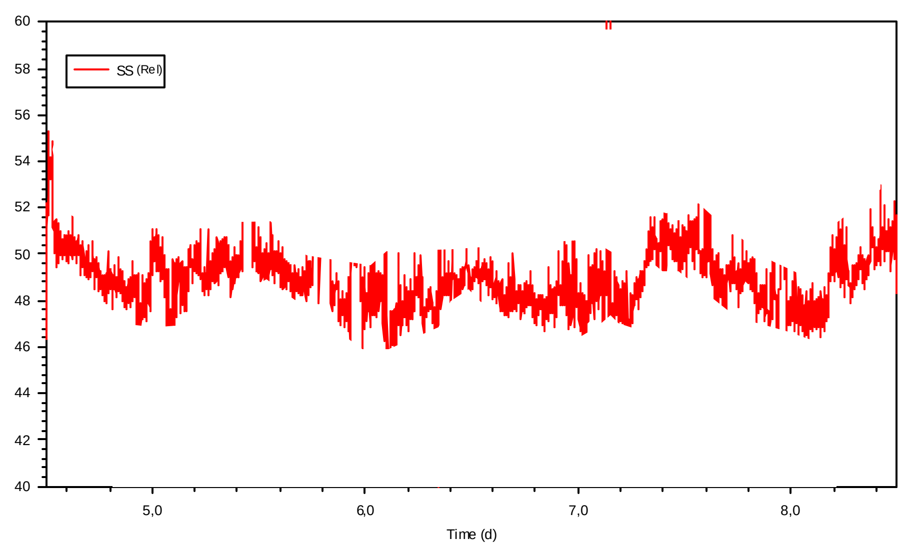
Details of power consumption which can be explained by aeration and operation of return sludge pumps is displayed in Fig. 1 . The power uptake of the return sludge pump is around 15 A. Also with respect to return sludge pumping some energy savings seem to be possible.

Current monitoring provides an excellent tool to continually observe and document some details of the plant operation.

8.6 Relative MLSS in Oxidation Ditch

On-line monitoring of the MLSS, a relative value which describes the level of biomass, in the oxidation ditch shows minor variations and a certain daily pattern. This is confirmed by the MLSS measurements as presented in Fig. 27

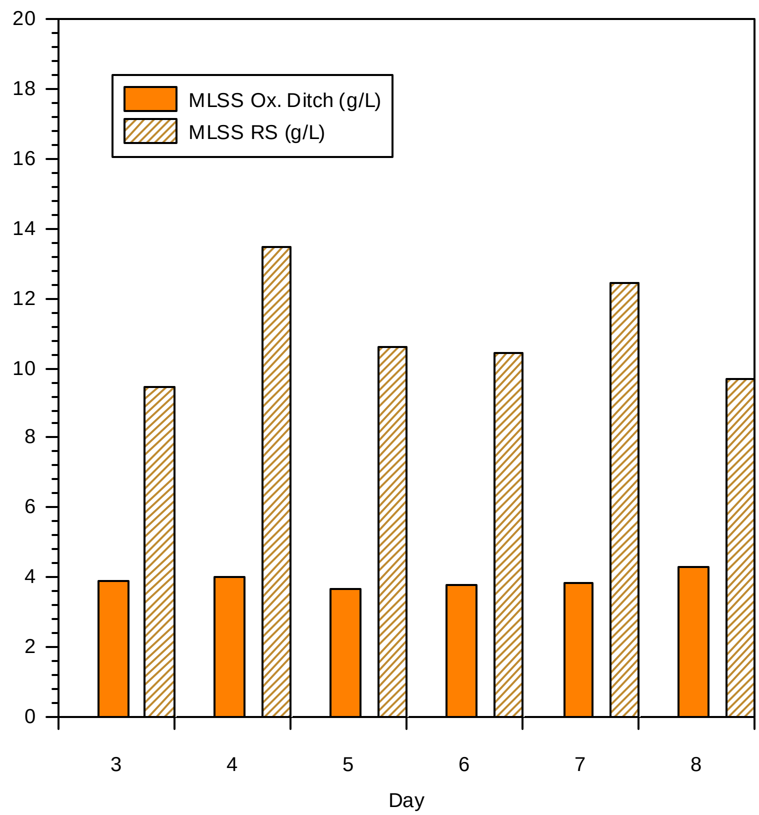
Fig. 26 On-Line MLSS in the Oxidation Ditch



8.7 MLSS and Sludge Activity

The micro-organisms concentration, expressed as mixed liquor suspended Solids (MLSS) of the oxidation ditch, is fairly constant over the whole week, with exemption of the last day. The MLSS of the return sludge varies a bit more, which could be explained by the variations in sludge concentration of the return sludge as shown in Fig. 27 .

Fig. 27 MLSS in the Oxidation ditch and Return Sludge



The sludge volume readings were taken three times per day. The volume has been fairly constant over the whole week and thus is not graphically presented. The values did not show a tendency other than being fairly constant. An example of the settling behaviour of one sample is shown in Fig. 28 . The 30-minute value is 860 mL/L. The volume reduces with time. After an hour the volume stays nearly constant and drops after around 5 hours to 400 mL/L. From this point onwards the compacting of the sludge starts.

The ratio of the MLSS of sludge from the oxidation ditch and the return sludge is a good representation of the influent return sludge flow ratio which is around 30 %, a bit lower than the value found based on the flow measurements. One of the reasons for this is that the return sludge flow was measured at high water levels in the return sludge sump. Since the capacity of pumps reduce at lower levels, this is one explanation for the lower values.

Since the sludge volume is far more than 250 mL/L, a dilution with effluent is recommended according to the methodology applied in Germany.

The slduge volume index (SVI) is the volume that is used by 1 g of activated slduge. This provides a quick impression of settleability. Values of 100 mL/g and less indicate good setlting sludge. The SVI of the undiluted sample was around 220 mL/g, which indicates strong bulking sludge. Applying the dilution method, the sludge volume index drops to 150 mL/g, still indicating bulking and very light sludge.

The sludge volume with the dilution method reached 400 mL/L, however not after 30 minutes, but after 3 hours. This indicates, that the present practice, of routine determination of the sludge volume over 30 minutes at the treatment facility, requires modifications.

Fig. 28 Activated Sludge Volume in the Oxidation Ditch

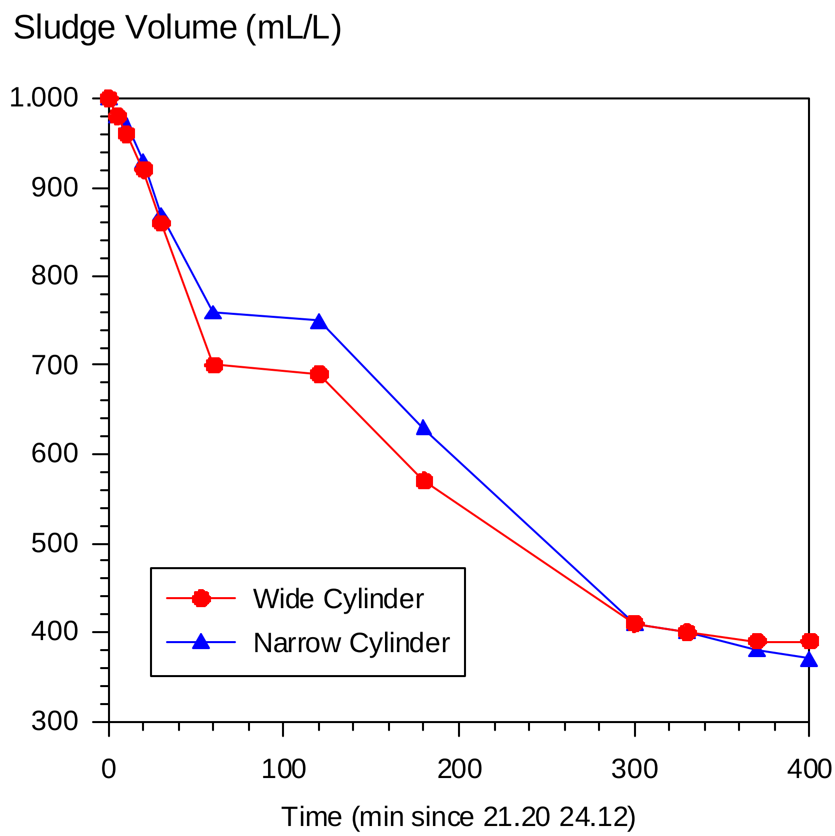
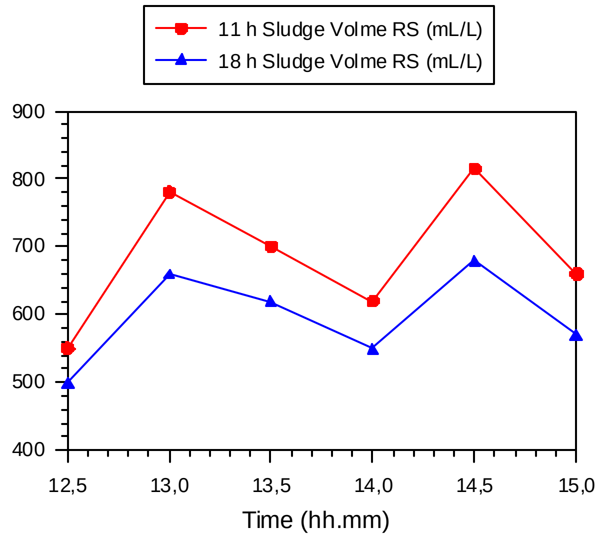
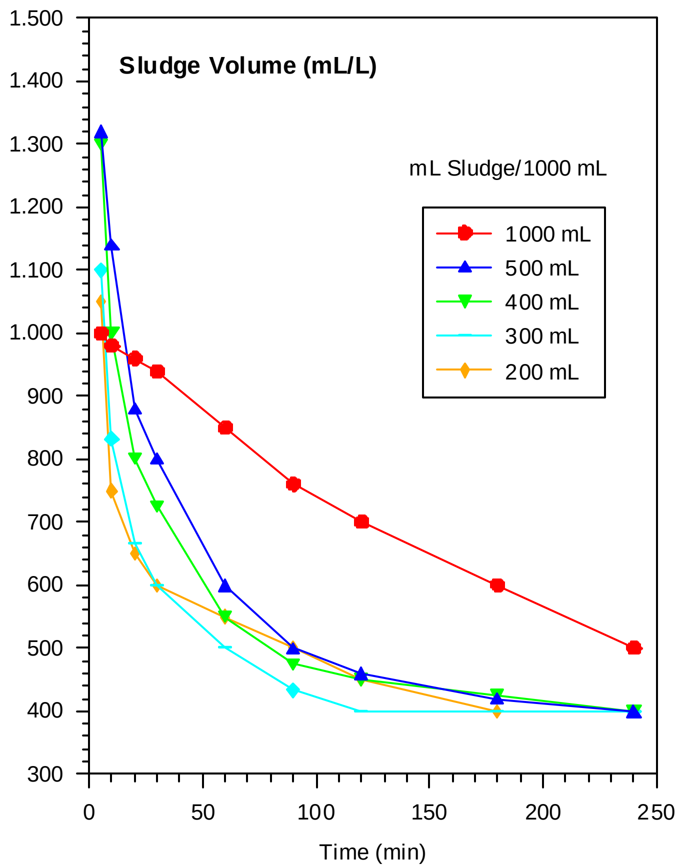


Fig. 29 Sludge Volume with Dilution



A series of return sludge samples has been taking over a short period of time (Fig. 30).

Fig. 30 Sequence of Sludge Volumes from Return Sludge

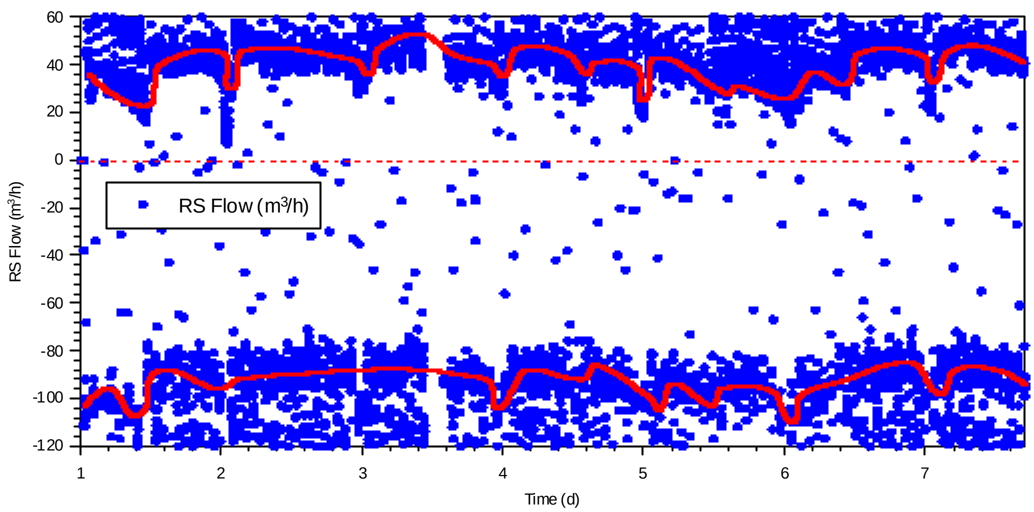


The values vary between 500 and 660 mL/L after 18 h settling. The settling time has been extended since no significant settling occurred during the first hour. In some other analysis the sludge sometimes started to float, indicating denitrification, a phenomenon which has never been observed at the surface of the sedimentation tank.

8.8 Return Sludge

The investigating team determined the return sludge flow based on the surface area of the return sludge sump. Since the area reduction in the deeper part of the sump was not know, the values vary strongly. The red lines indicate the approximate return sludge flow into the sump and out of the sump. The latter has to be increased by the continual flowing return sludge to obtain the real capacity of the return sludge pump.

Fig. 31 RS Flow into and from the RS Pump Sump (Flow into Contact Tank)



Return sludge flows over 22 – 26 minutes. The flow into the contact tank is at maximum 26/60 x (40 + 100) = 60 m^3/h. In relation to the waste water flow into the contact tank, the average return sludge ratio is 60/111 * 100 = 54 %, a value that is in an acceptable and expected range.

Observations of the return sludge quality showed on few occasions that the sludge content in the return sludge seemed to decrease. This indicated that during this time the return sludge ratio could have been reduced. Under no circumstances a sludge bed rise was observed in the sedimentation tank. Both observations demonstrate that the solids residence time in the sedimentation tank is most probably around the minimum.

A proper adjustment of the return sludge amount is required to avoid to much accumulation in the sedimentation tank, but also the bring the influent into proper contact with the return sludge in the contact tank and to maintain a sufficiently high micro-organisms in the oxidation ditch for proper waste water treatment. When this level reaches the point that plant performance deteriorates, surplus sludge must be removed from the system.

8.9 Effluent: E. Coli and Settleable Solids

The Faecal Coliform concentration was 25000 MPN/100 mL which is in a similar range as the NWC effluent analytical data (see appendix).

Settleable solids were determined (Imhoff Cone) of the composite effluent samples. Only on Saturday that a grab sample taken after cleaning the scum collector area of the sedimentation tank had some suspended solids. All the other effluent samples were crystal clear and contained no settleable matter at all.

8.10 Scum

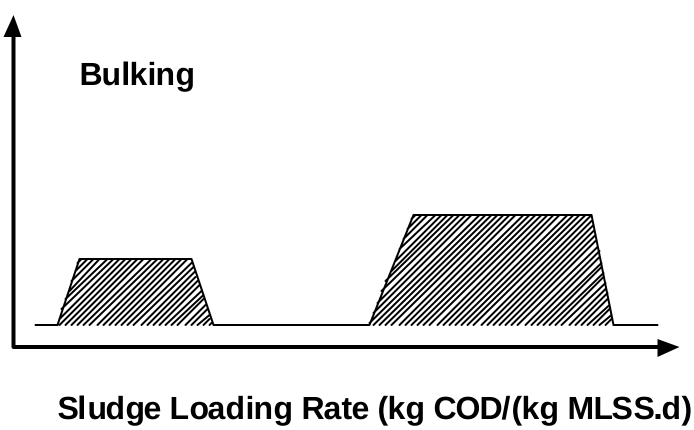
The oxidation ditch contained a scum layer which, appeared at first glance, to be mainly grease, oil and suspended matter. This scum is removed on a daily basis from the surface of the contact tank. Since there is no proper baffle at the overflow weir of the oxidation ditch at all times, the scum is displaced to the sedimentation tank, where little scum is found on the surface. The scum removal equipment of the sedimentation tank is insufficiently sized to remove the scum from the surface. Also the scum outlet clogs from time to time.

The scum forms large bubbles which are more typical for certain types of bulking sludge. The scum may cause optically problems, however it does not result in a reduced effluent quality, unless the scum of the sedimentation tank is pushed into the effluent launder during cleaning. In order to retain the sludge in the oxidation ditch a modification at the overflow weir is required.

8.11 Microscopic Examination of Activated Sludge

The activated sludge at the beginning and the end of the investigation week, but also a sample taken in January 2001, was viewed under the microscope. Basically the sludge showed the same pattern at all occasions: No dark clusters in flocs, but bacteria grown along the thread forming bacteria (bulking), very few protozoa were seen. This is also unusual for a well-aerated sludge. The heavy bulking sludge is at first glance unusual for a low loaded activated sludge process with a contact tank. The sludge volume index (SVI (mL/g)) is a good indicator for bulking. The next general figure shows a general view with respect to bulking. With respect to bulking, there are many publications. During a conference in Japan, Mr. Henk Rensink, lecturer at Wageningen University in the Netherlands, indicated findings which clearly show a high correlation of bulking sludge with the feeding pattern (continual and batch wise). In around 75 % of the cases equalised feeding is one of the causes for the existence of bulking sludge in the aerobic activated sludge process.

Fig. 32 Schematic Diagram of Bulking Sludge



8.12 Final Effluent Quality

Tab. 3. shows the NRCA standards, as listed in the Negril Wastewater Operations Protocol of May 2000, compared to the Ocho Rios treatment plant performance.

Tab. 3. NRCA Standards and Compliance November 2000

	Unit	NRCA-Standard	Ocho Rios December 2000
COD	mg/L	< 100	met
BOD	mg/L	< 20	
TSS	mg/L	< 30	met
DO	mg/L	> 4	partly met
pH	-	6 - 9	ok
Conductivity	mS/cm	< 0.4	not met
Total - Nitrate	mg/L	< 10	not met
Total - Phosphate	mg/L	< 4	not met
Faecal Coliformes	MPN	< 1100	not met
Ammonia-N	mg N/L	none	acceptable

8.13 Summary of Major Findings

The following summarise the major observations during the monitoring of the Ocho Rios sewage treatment ponds:

- The Flow meter provides reliable data about flow into the treatment plant, however the signal cannot be read and the control panel.
- Flow into the treatment plant was around 2600 m^3/d.
- The return sludge ratio was around 50 %
- The oxidation ditch was predominantly aerobic
- Nitrate content in the effluent was relatively high, indicating options to improve denitrification and energy savings.
- Significant odours occurred sometimes at the inlet.

- Scum removal and aerosol could be one of the explanations for the fact that hardly surplus sludge is being produced.

- Aerosol formation at the brush aerators is significant.

- Average HRT of the wastewater in oxidation ditch is 2,0 d and in the sedimentation tank is 0,7 d.

- COD loading rates are low. They vary between 0,05 and 0,24 kg/(m^3.d) at MLSS of around 4 g/L.

- Surplus sludge production is less than expected. The sludge thickens and dewaters well. However, there is a need to slope the sludge drying beds different so that the sludge layer is equal all over the bed. A definition for dried sludge has to be established, supported by empirical measurements at the site.

- Plant effluent does not meet all NRCA standards and would be considered a significant aspect for the EMS.

9 EXISTING DATA

Existing data was received from NWC and reviewed by the consulting team. The details the consultants review have been placed in the appendices for reference.

10 ENVIRONMENTAL ASPECTS

This is intended as initial environmental review to identify environmental aspects, which should form the basis for the development of an environmental management programme.

Tab. 4. Summary of Environmental Aspects

Activity / Service	Aspects	Impacts	Quantification of Aspects	Ocho Rios Level of Significance
Inflow	Odour release	Air pollution	H_2S	-
		Corrosion	Observation	o
Lighting	Use of energy	Resource depletion	Power consumption	o
Desludging Drying Beds	Solid waste	Landfill	Volume, Solid content	--
		Agricultural Applications	Volume, Solid content	+
Scum removal	Solid waste	Landfill	Volume, Solid content	-
Treatment	Denitrification	Resource depletion	Nitrate Concentration	--
	Aeration	Resource depletion	Power consumption	--
	Aerosol	Air pollution	Bacterial Counts	-
Operation	Outflow	Water pollution	Organics (COD)	o
	Outflow	Water pollution	Organics (BOD)	o
	Outflow	Water pollution	Organics (SS)	o
	Outflow	Water pollution	N	-
	Outflow	Water pollution	P	--
	Outflow	Water pollution	Pathogens (Faecal Coli)	-

- **-** or + = significant negative or positive
- = very significant
- = slight or moderate

11 CONCLUSIONS

The investigations of the treatment system indicate that there is no great variability in the overall treatment performance. However there are significant improvements possible with respect to energy saving and denitrification.

Without additional equipment and experience in on-site monitoring and process control, it will be difficult to achieve the energy savings without endangering a deterioration of the effluent quality. Given the presence simple process control modifications, a proper response is possible and economically viable.

Surplus sludge production and drying requires attention. Equipment for determining the solids content of the different sludge should be available on-site so that not only the bulking can be documented, but also the sludge thickening and drying process is supported with empirical data on a daily basis.

The introduction of environmental management systems supported by more effective data collection and an interactive training approach (on the job) can result in improvements in plant performance and a reduction in operational costs. Indeed these changes should be incorporated in the management plan.

It is our recommendation therefore that for Ocho Rios the implementation of the EMS should involve a consideration of this report as well as a full and detailed capacity assessment report.

TREATMENT PLANT OVERVIEW

Pict. 1. **Aerial view showing location of the monitoring tent**

Pict. 2. **Overview of the Treatment Plant showing Reynolds loading pier in background**

Pict. 3. **Outflow weir of the Oxidation Ponds**

Pict. 4. **Secondary Sedimentation tank (not in operation)**

Pict. 5. **Scum layer on the sedimentation tank**

Pict. 6. **Automatic screen for inflow**

Pict. 7. Screen

Pict. 8. Collection of screenings

Pict. 9. **Screen**

Pict. 10. **Screen**

Pict. 11. **Overflow weir at the Oxidation ditch**

Pict. 12. **Sludge Drying Beds**

Pict. 13. Sludge Drying Beds

Pict. 14. Sludge Drying Bed recently filled

Pict. 15. **Contact Tank**

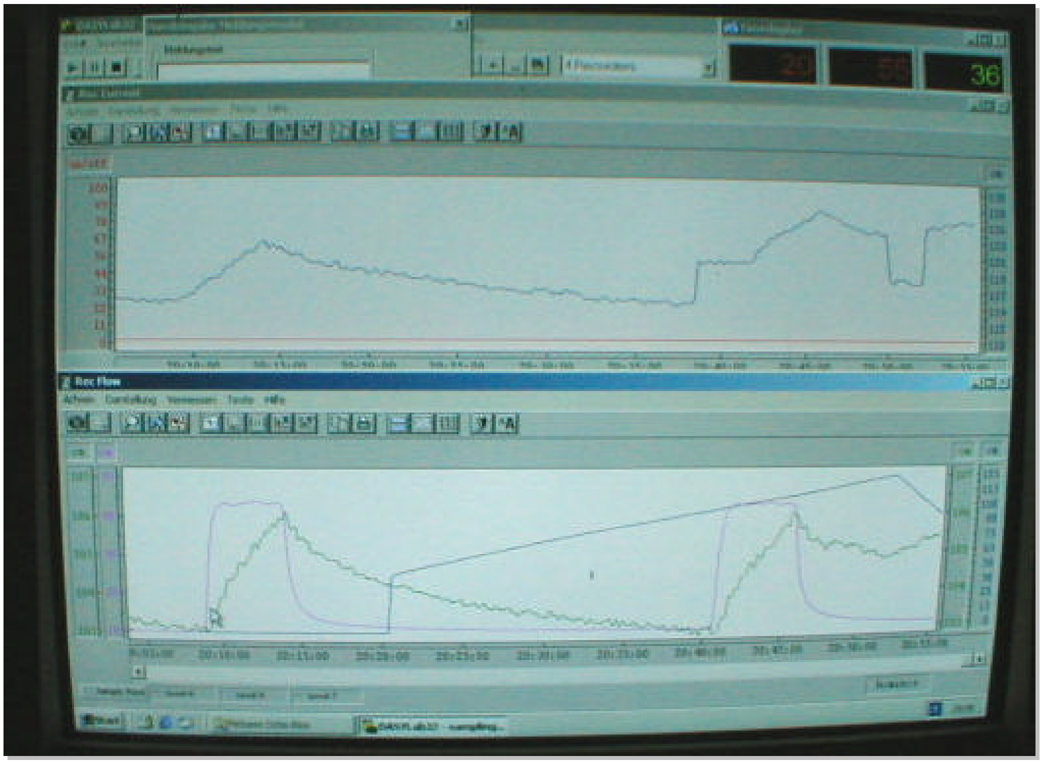
Pict. 16. **Aerators**

Pict. 17. Influent to the Screen

Pict. 18. Inflow

Pict. 19. Location of Monitoring Tent

Pict. 20. Return Sludge and Inflow



Pict. 21. Monitoring Screen

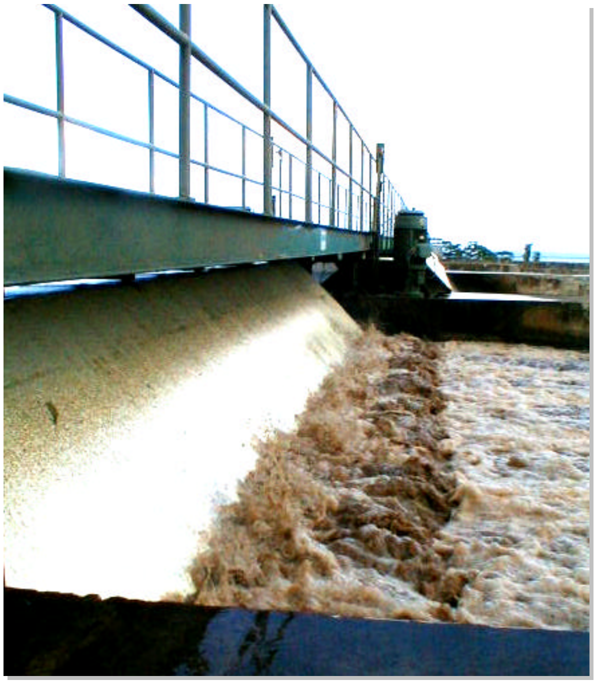
Pict. 22. Sample Measurement

Pict. 23. **Monitoring Equipment**

Pict. 24. **Return Sludge from Sedimentation Tank to Oxidation Tank**

Pict. 25. Return Sludge from Sedimentation Tank to Oxidation Tank

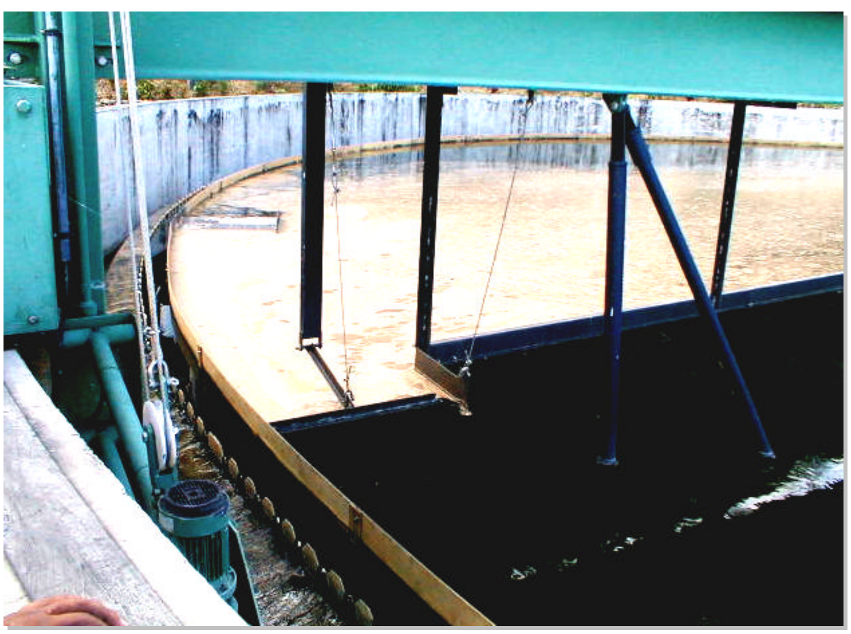
Pict. 26. Aerators at the outflow



Pict. 27. **Details of Aerator at the Outflow**

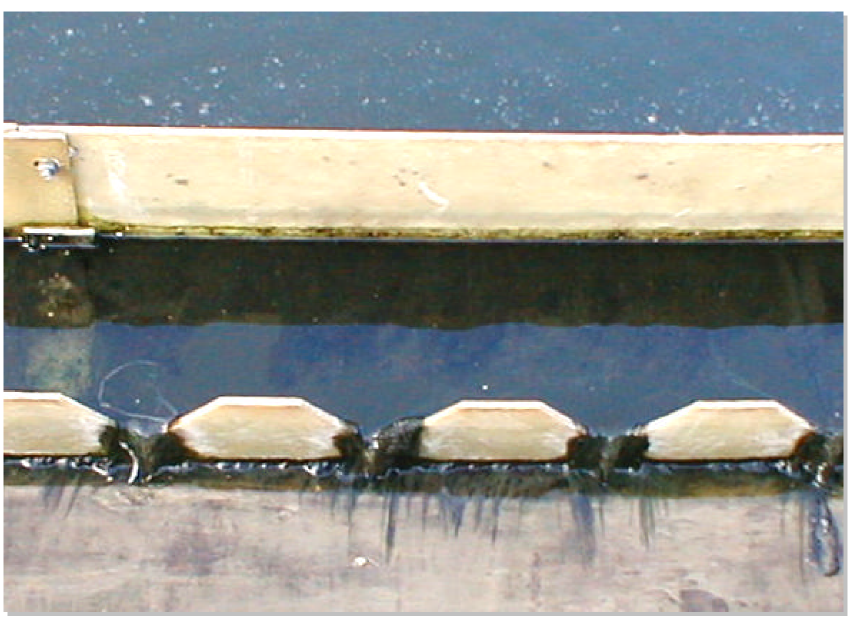
Pict. 28. **Outflow weir with baffle**

Pict. 29. **Details of Outflow weir with baffle**



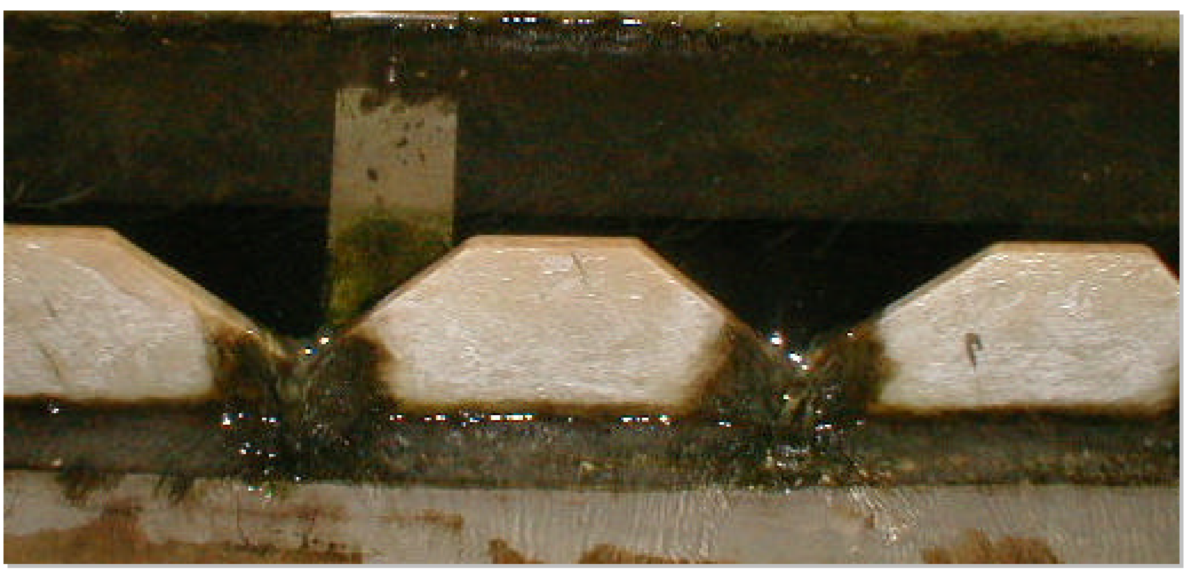
Pict. 30. **Sedimentation Tank**

Pict. 31. **Sedimentation Tank**



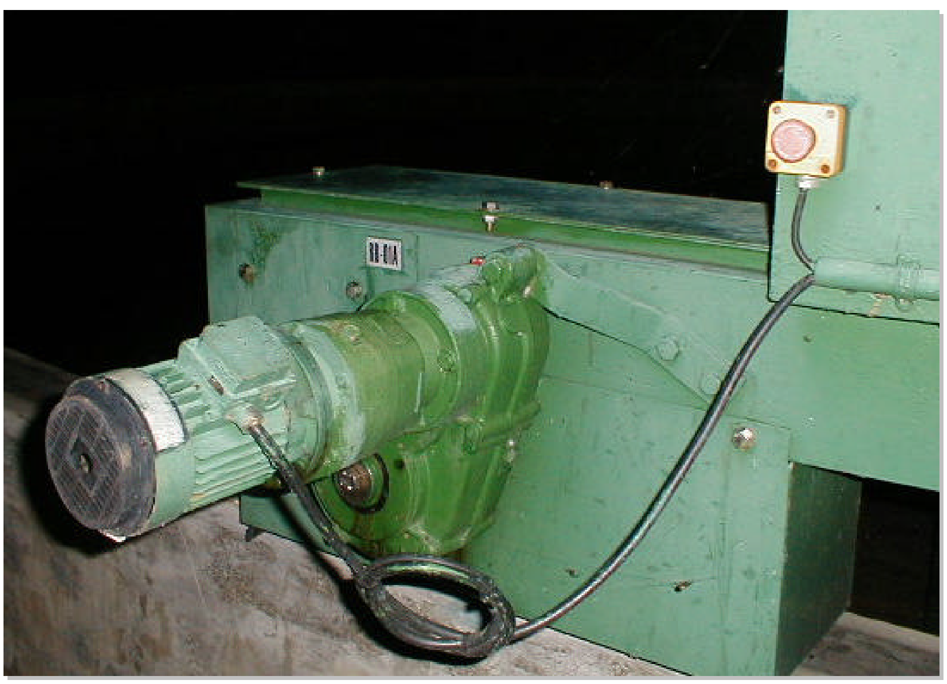
Pict. 32. **Outflow weir of the Sedimentation Tank**

Pict. 33. Outflow weir of the Sedimentation Tank



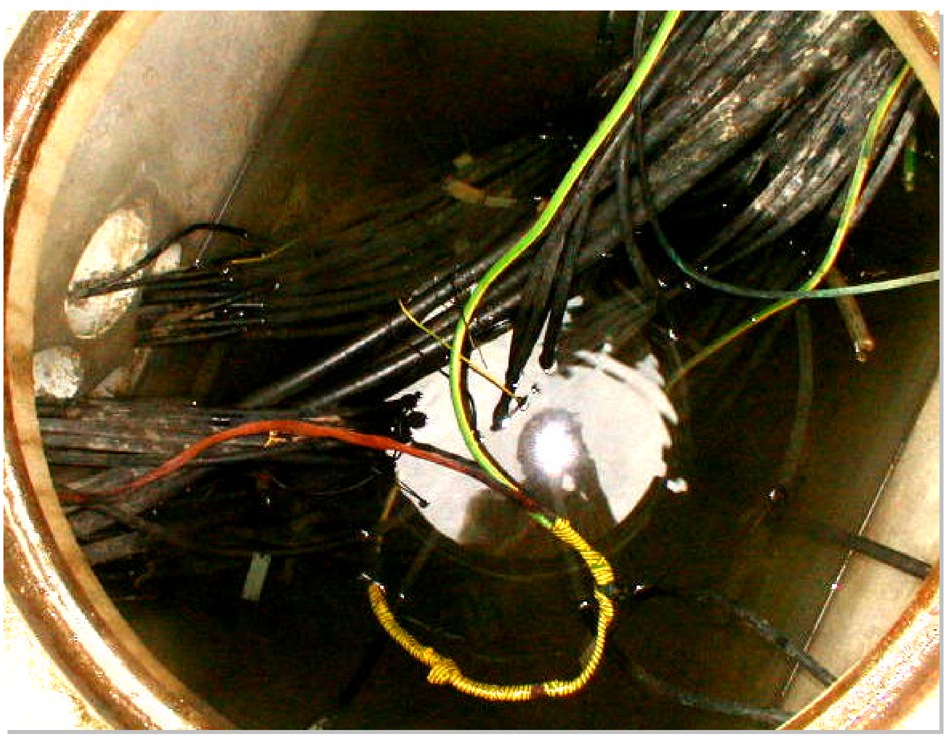
Pict. 34. Outflow weir of the Sedimentation Tank

Pict. 35. Flowmeter at Influent



Pict. 36. Driver of bridge on Sedimentation Tank

Pict. 37. Return sludge valves



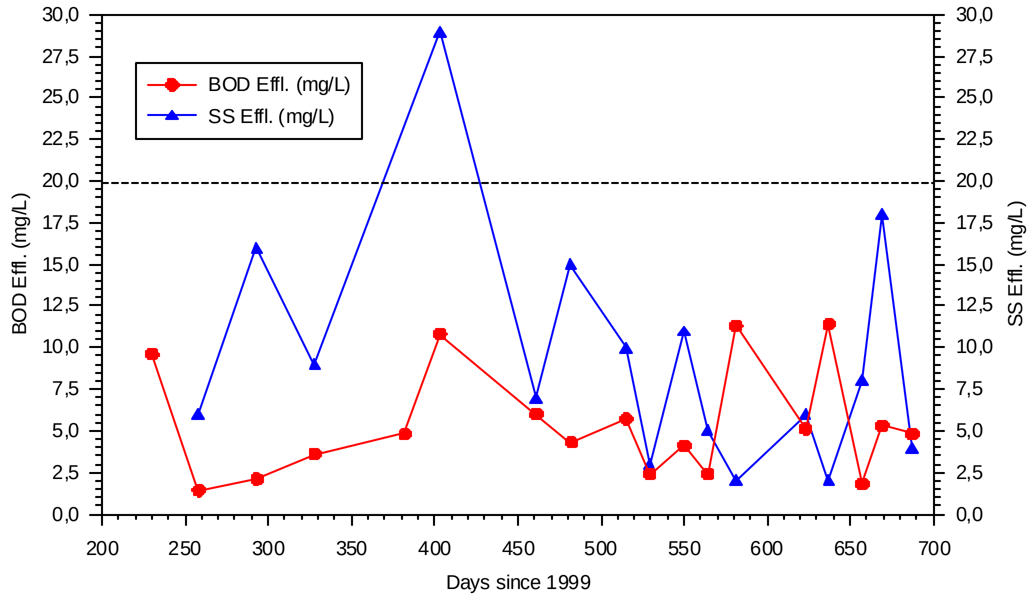
Pict. 38. Water in a cable shaft

Pict. 39. **Corrosion on screen cover**

12 NWC DATA

12.1 BOD and Nitrate

Fig. 33 BOD and Nitrate in the Effluent



12.2 PO4 and SS in Influent

Fig. 34 PO_4 and SS in the Influent

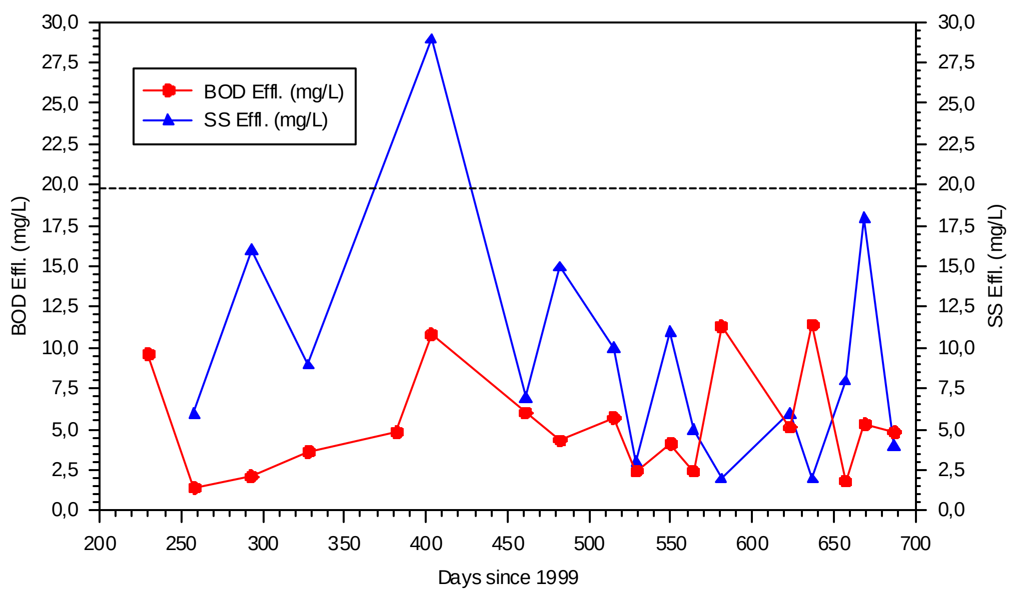
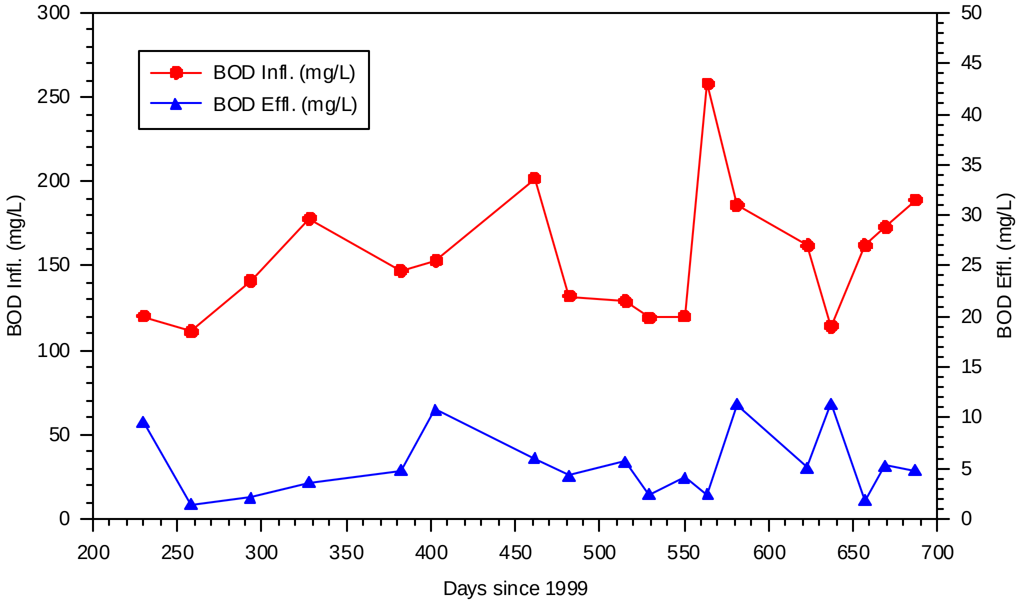
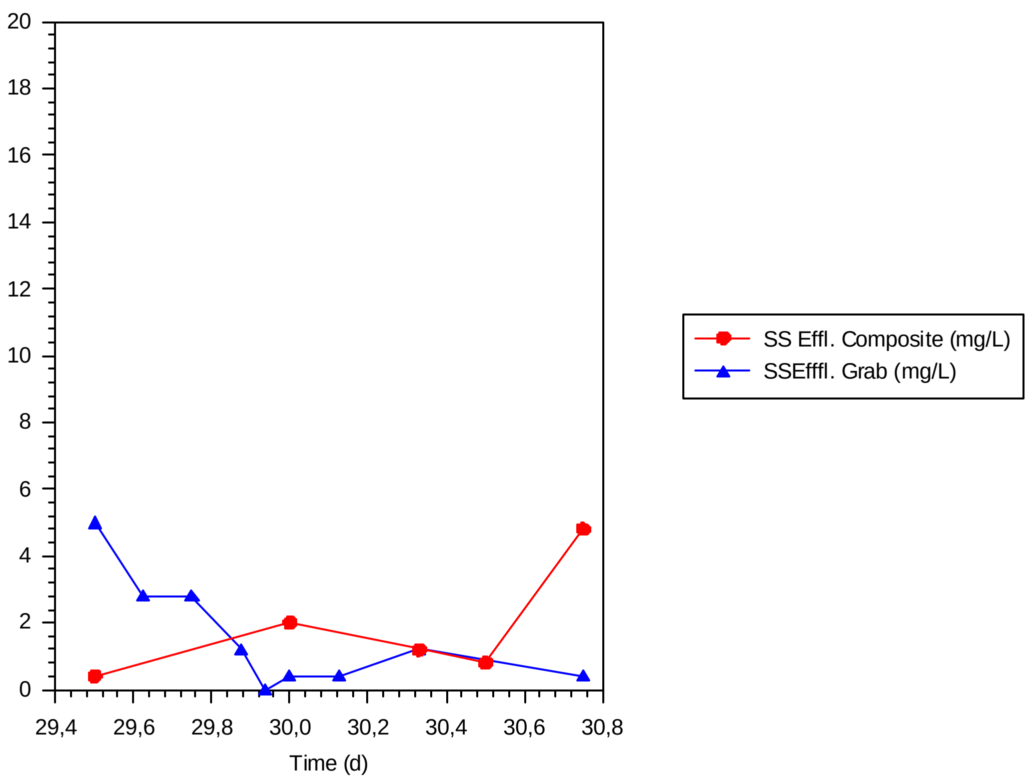


Fig. 35 BOD in Influent and Effluent

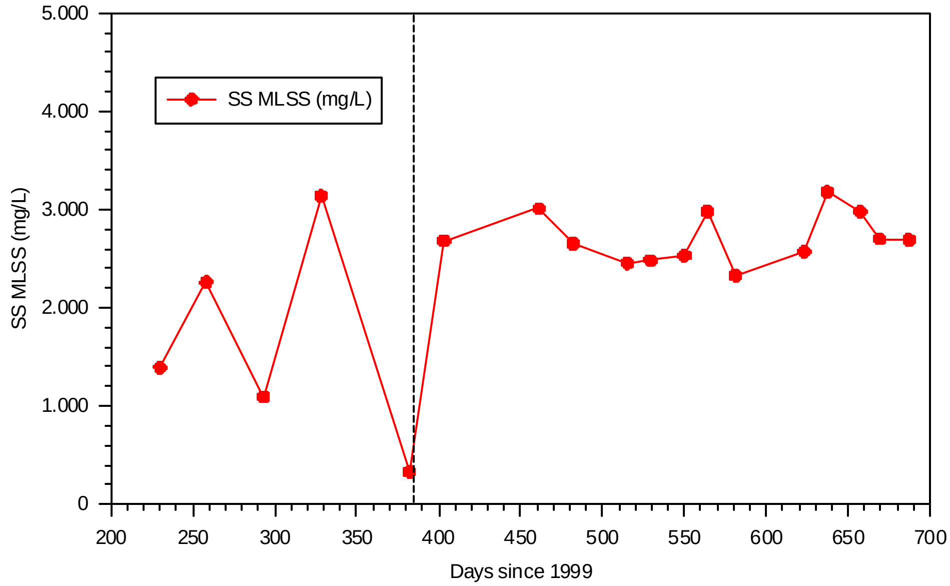


12.3 SS and MLSS

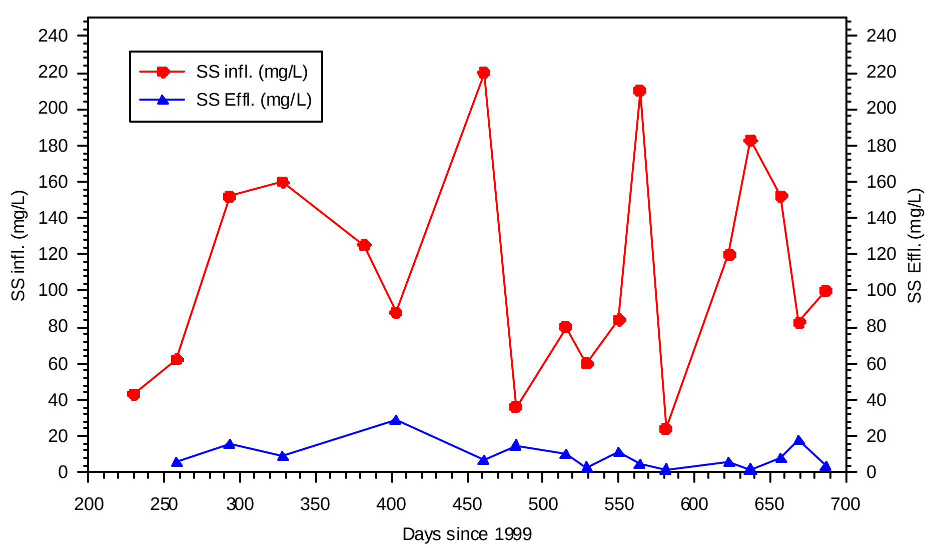
Fig. 36 Phosphate in first Pond in Series and Effluent



Tab. 5. **Suspended Solids in first Pond in Series and Effluent**

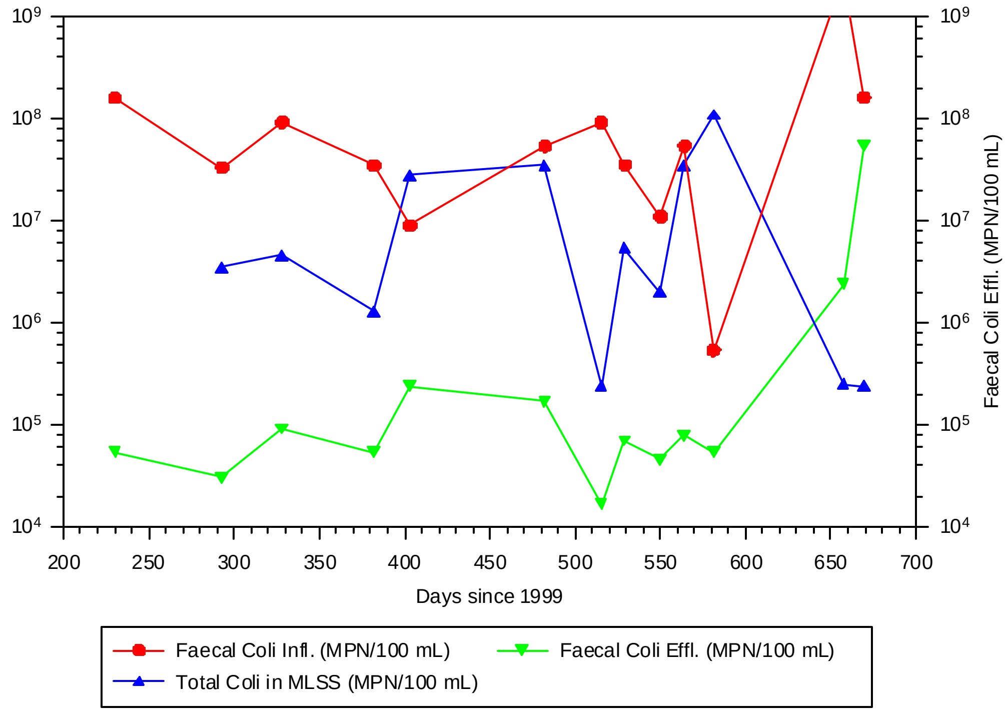


Tab. 6. **MLSS**



12.4 Faecal Coli

Fig. 37 Faecal Coliforms



CWIP

Coastal Water Quality Improvement Project