An Investigation Of Biological Treatment And Aeration
On Wastewater Effluent

By

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Abstract

Environmental analysis shows that effluent streams have been found to fall frequently outside the pH specified by the local authority in to whose sewer the wastewater is discharged. The accumulation of oils, fats and greases also poses a challenge to the industry as its disposal is becoming more restrictive and costly.

The aim of this project was to determine if it was feasible to treat effluent in grease traps, onsite, biologically by the method of Biological Aerated Filter Treatment to effect a decrease on the loading of the grease thus bringing the wastewater quality parameters within the required specification while maintaining a specified pH range of 6-10.

A laboratory scale model of a grease trap, containing various effluent samples similar in concentration and composition to that entering the grease traps on site, was treated biologically by an attached growth system comprising of a microbiological population in contact with a substrate (PVC) to metabolise the target waste and so decrease the loading in the model grease trap. The tank was also aerated to eliminate anaerobic conditions which may lead to fermentative involving a certain amount of acid production thus maintaining an acceptable pH 6-10. Two of the nine grease traps on site were also monitored to investigate the loading on the traps.

The laboratory scale study revealed a decrease in all parameters of the wastewater quality to within the licencing limits, while effecting a rise in the pH to an average 6.3 pH units. However the study revealed a certain start up period / lag phase before optimal biological activity occurred .The time in which it took for the wastewater quality parameters to reach satisfactory levels was found to be outside the residence time available for wastewater effluent in the grease traps on site.

It is evident by the laboratory project that the biological aerated system is successful in regulating the quality parameters, but it is also clear that longer residence times are required to optimise the performance of the biological aerated filter system. Larger scale treatment facilities are required to ellivate such factors as residence time and flow rates thus optimising the performance of the biological treatment system.
Acknowledgements.

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Abbreviations

Biological Aerated Filter (BAF)
Biochemical Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Oils, Fats & Grease (OFG)
Environmental Protection Agency (EPA)
Kilogrammes per day (kg/day)
Milligrammes per day (kg/day)
°C (degrees Celsius)

Treatment A : non-biological / non-aeration
Treatment B : aeration
Treatment C : biological concentrate / non-aeration
Treatment D : biological concentrate / aeration
Treatment E : biological concentrate / biofilter / aeration
1. Introduction

1.1 Introduction

This project was undertaken at Cadbury’s Ireland Ltd in Coolock, Dublin. Cadbury Ireland Ltd is part of the multinational Cadbury Schweppes group which markets and distributes its confectionery and beverages products in almost 200 countries worldwide. As a major global group, Cadbury recognises their important responsibilities in caring for the local and global environment. As stated in their environmental policy, Cadburys Schweppes ‘see sound and responsible environmental management as an integral part to ensure that they minimise the environmental impact of their activities on the world around us’.

1.2 Industrial Effluent

Industrial effluents can be considered to be any liquid waste product, discharged from a factory, or industry which is not recycled back into the work process. The food industry includes several different production processes. The wastewater from the various processes varies considerably as the composition of the product will influence the composition of the wastewater (Jorgensen, 1988).

If untreated wastewater is allowed to accumulate, the decomposition of the organic materials it contains can lead to the production of large quantities of malodourous gases. The sewage treatment process relies upon the processes of settlement of solids, and biological oxidation of the remaining pollutant matter. The strength of effluents is based upon suspended solids present, and biochemical oxygen demand, (BOD). (Jefferys)

1.2.1 Current Environmental Position

The food industry affects the environment through the discharge of wastewater to surface water courses and sewers. The changes in legal and social obligations both nationally and within the EC are making it necessary for all food processing industries to adopt a more professional approach to
wastewater management. Cadburys are currently facing environmental challenges relating to the disposal of oils, fats and greases and the quality of the water entering the river at various outfalls.

**Project Objective:**

In order to be consistent with current local authority wastewater limits the objective of this project is to monitor the effect of biological aerated treatment with a view to decreasing wastewater parameters such as BOD, COD, SS and OFGs while maintaining a pH within the specification of 6-10.

The only previous existing preliminary treatment present for oils, fats, and greases on site were grease traps which work on the principle of flotation. There are nine such devices scattered around the premises to remove the solids content which consists of fatty wastes from the effluent leaving the processing sites. Each system consists of three traps positioned in series. The system is an effective and hygienic method of separating fat and grease from wastewater flow. However the disposal of the accumulated oil, fats, and grease remains an obstacle environmentally for the food industry. The number and capacity of landfills have been reduced and new landfill locations that meet environmental, social and economic requirements are increasingly difficult to find and so an alternative method for the elimination of oils, fats, and greases is required.

- **Grease Trap**

  Is a system (underground tank) designed to capture oil and greases on site from the waste exiting the plant. Grease traps which work on the principle of floatation. In wastewater treatment, floatation is principally used to remove suspended matter and to concentrate biological sludge.

Suspended material rise or falls depending on whether its density is less or greater than that of water. Once the particles have floated to the surface they can be collected by a skimming operation by external contractor. *(Environmental Engineering Science, 2000)*
Health authorities today agree that the disposal of effluent into lakes and rivers is satisfactory if it contains not more than 30ppm of suspended solids and does not absorb more than 20ppm of dissolved oxygen in 5 days. The problem of waste streams frequently falling outside the pH range specified by the local authority is also an obstacle to be overcome. The application of biological treatment is selected for producing effluent which meets the required standards for wastewaters.

At the present time, most of the unit operations and processes used for wastewater treatment are undergoing continual and intensive investigation from the standpoint of biological standards. (Metcalf, 1998). After treatment wastewater must either be reused or disposed of to the environment. If an adverse environmental impact is to be avoided, the quality of the treated and dispersed must be consistent with the local water quality objectives as stated in Section 1.3.

- **Flow measurement**

Accurate flow measurement at the grease trap, the discharge to the watercourse is essential. Flow records are necessary for any mass balance calculations through the plant. Most regulatory bodies place upper discharge rates/hrs and a 24 hr total flow to avoid flooding, inadequate dilution of the effluent in a river or treatment difficulty at the local works caused by sudden shock loads. (John Arundal, 1995)
• Retention Time (RT)

This is the time that waste spends in the treatment reservoir (grease trap), it is dependent on the volume of the reservoir and the flow rate through the reservoir.

1.3 Licencing of Wastewater Discharge in Ireland & Importance of Wastewater Monitoring

The quality of wastewater discharges in Ireland has traditionally been controlled by the use of physical and chemical parameters, albeit with some knowledge of their biological effects. Local authorities have increasingly requested information derived from laboratory tests to control the quality of wastewater discharges.

Primary responsibility for the control of the water pollution rests with the local authorities. The necessary powers to fulfill this responsibility are provided in the Water Pollution Acts 1997-1990. Section 16, which makes it an offence to discharge trade or other effluent to sewer save in accordance with a licence issued by the local authority. It is important that an industrial wastewater discharge is characterised so that its impact on the receiving environment is assessed and to assist in the identification of priority actions to eliminate / reduce hazardous substances.

When industrial wastewater has been characterised licence conditions can be drafted to protect the aquatic environment which receives treated wastewater and landfill where residues are deposited. (Environmental Protection Agency, 2000).

The existing licencing limits for Cadbury Ireland set down by the local authority are as follows:

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Units</th>
<th>Target</th>
<th>Environmental Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>ppm</td>
<td>6000</td>
<td>&lt; 6000</td>
</tr>
<tr>
<td>BOD</td>
<td>ppm</td>
<td>3000</td>
<td>&lt;3000</td>
</tr>
<tr>
<td>OFG</td>
<td>ppm</td>
<td>600</td>
<td>&lt;600</td>
</tr>
<tr>
<td>SS</td>
<td>ppm</td>
<td>1500</td>
<td>&lt;1500</td>
</tr>
<tr>
<td>PH</td>
<td>pH units</td>
<td>8</td>
<td>6-10</td>
</tr>
</tbody>
</table>
1.4 Parameters Used To Evaluate The Quality Of Wastewater

1.4.1 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is the amount of oxygen, expressed in mg/l or ppm, that bacteria can take from water when they oxidise organic matter. The carbohydrates, proteins, petroleum hydrocarbons and other materials that comprise organic matter get into the water from natural sources and from pollution. BOD is the most commonly used parameter to define the strength of a municipal or organic-industrial wastewater. Its widest application is in measuring the waste loading to treatment plants and evaluating the effluent of such treatment systems.

When organic matter is discharged into a watercourse it serves as a food source or later commence the breakdown of this matter to less complex organic substances and ultimately to simple compounds such as CO₂ and H₂O. If previously unpolluted, the receiving water will be saturated with dissolved oxygen (DO) or nearly so and the bacteria present in the water will be aerobic types. Thus the bacterial breakdown of the organic matter added will be an aerobic process – the bacteria will multiply degrading the waste and utilising the dissolved oxygen as they do so. (P.J. Flanagan, 1992).

The BOD test is used to determine the relative oxygen requirements of treated effluents and polluted waters. If the quantity of the waste present is sufficiently large the rate of bacterial uptake of oxygen will outstrip that at which dissolved oxygen is replenished and ultimately the receiving H₂O will be anaerobic.

1.4.2 Chemical Oxygen Demand

The chemical oxygen demand is widely used as a means of measuring the organic strength of domestic and industrial wastes. The COD test allows measurement of a waste in terms of the total quantity of oxygen required for oxidation to carbon dioxide and water in accordance with the equation;
COHNS + O₂ + Nutrients → CO₂ + NH₃ + C₅H₂O₂ + other end products

It is based upon the fact that all organic compounds, with few exceptions, can be oxidised by the action of strong oxidising agents under acid conditions.

During the determination of COD, organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. For example, glucose and lignin are both oxidised completely. As a result, COD values are greater than BOD values and may be much greater when significant amounts of biologically resistant organic matter is present. One of the chief limitations of the COD test is its inability to differentiate between biologically oxidisable and biologically inert organic matter. In addition, it does not provide any evidence of the rate at which biologically active material would be stabilised under conditions that exist in nature. (Clair N. Sawyer, 1994)

The major advantage of the COD test is the short time required to evaluation. The determination can be made in about 3 hours rather than the 5 days required for the determination of BOD. For this reason it can be used as a substitute for the BOD test in many instances. COD data can often be interpreted on terms of BOD values after sufficient experience has been accumulated to establish reliable correlation factors.

1.4.3 Suspended Solids

Matter which is suspended in quiescent water consists of finely divided light solids which may never settle or do so very slowly. Indeed the net effect may be one of apparent turbidity without any discernible solids. In flowing water, on the other hand, the solids which are kept in suspension by the turbulence may be settleable if the water is let stand. To determine as much as possible of the solids present, but not in the solution, the determination of “suspended” solids is carried out.

The significance of suspended solids in water is great, on a number of grounds. The solids may in fact consist of algal growths and hence be indicative of severely eutrophic conditions; they will reduce light penetration in surface waters and interfere with aquatic plant life; they will seriously damage fishery waters and may affect fish life; they may form deposits on the bed of rivers and
lakes which in turn give rise to septic and offensive conditions; and they may indicate the presence of unsatisfactory sewage effluent discharges.

1.4.4 Oils, Fats And Greases

Fats and oils are the third major component of foodstuffs. The term “grease,” as commonly used, includes the fats, oils, waxes, and the other related constituents found in wastewater. Fats and oils are compounds (esters) of alcohol or glycerol (glycerin) with fatty acids. The glycerides of fatty acids that are liquid at ordinary temperatures are called oils, and those that are solid are called fats. They are quite similar, chemically, being composed of carbon, hydrogen, and oxygen in varying proportions. (*Metcalf, 1991*).

Their importance in industrial wastes is related to their difficulty in handling and treatment. Because of their low solubility, grease separates from water adhering to the interior of pipes and tank walls, reduces biological treatability of a wastewater, and produces greasy sludge solids difficult to process. (*Mark J. Hammer, 1996*).

Fats are among the most stable organic compounds and are not easily decomposed by bacteria. The grease content of wastewater can cause many problems in both sewers and wastewater treatment plants. If the grease is not removed before discharge of the waste, it can interfere with the biological life in the surface waters and create unsightly floating material and films.

1.4.5 pH

The measure of the relative acidity or alkalinity of a solution is called its pH. The pH value is expressed a no from 0-14. Acidic substances have pH less than 7 whereas pH values above 7 indicate increasing alkalinity. The pH of most mineral waters is 6-9. The pH remains reasonably constant unless the water quality changes due to natural or anthropogenic influences, adding acidity or basicity. As most ecological life forms are sensitive to pH it is important that the anthropogenic impact of the effluent discharged be minimised. (*Gerard Kiely, 1996*).
In wastewater treatment it is seen that pH control of wastewater influent to biological systems is important to maintain within a specific range. An influent pH too far to one side of the acceptable range (6-8) may kill the active microbiological population to untreated effluent discharges. Organisms can be affected by acidification either directly physiological stress or indirectly by such changes as food supply, habitat provision and predation. As expected the ecosystem response to acidification is very complex, indicating the complexity of both ecological and pollutant processes. Microbial activity seems to be reduced with reduced decomposition.

1.5 Biological Treatment

The objectives of biological treatment of waste waters are to coagulate and remove the nonsettleable colloidal solids and to stabilise the organic matter. The removal of carbonaceous BOD, the coagulation of non-settleable colloidal solids and the stabilisation of organic matter are accomplished biologically using a variety of microorganisms principally bacteria. The microorganisms are used to convert the colloidal and dissolved carbonaceous organic matter into various gases and into cell tissue. Because cell tissue has a specific gravity slightly greater than that of H2O the resulting cells can be removed from the treated liquid by gravity settling. (Eddy.1991)

1.5.1 Attached Growth Systems

Attached growth systems are biological treatment processes in which the microorganisms responsible for the conversion of the organic matter or other constituents in the wastewater to gases and water. Cell tissue are attached to some inert medium rocks, or specially designed ceramic or plastic materials. Attached growth treatment processes are also known as fixed-film processes. When effluent is first applied to a new biological filter the medium is soon covered with a slime. This slime is the microbial ‘film’ which, by feeding on the organic matter in the settled sewage, is responsible for the removal of BOD.
The micro-organisms of the film use the organic matter as (i) a respiratory substrate which they oxidise to provide the energy for their life processes, and (ii) a material for synthesis for growth and multiplication (Fig. 1.2).

Fig. 1.2 Synthesis and energy production in biological oxidation of organic matter

Organic waste is introduced into the grease trap where an aerobic bacterial culture is maintained in suspension. In the reactor, the bacterial culture carries out the conversion on general accordance with the stoichiometry shown below.

- **Purification:**
  Is the removal of the pollutants from the settled sewage by physical absorption onto the microbial surfaces.

Fig 1.3 : Enzymatic hydrolysis and bacterial breakdown of organic residues.
Organic matter is firstly physically absorbed by extracellular enzymes secreted by the micro-organisms. In this process of hydrolysis, to smaller molecules, which are then absorbed by the cell. Within cell the substrate may be metabolised immediately or converted into storage products such as glycogen for subsequent metabolism while producing natural inorganic substances such as $H_2O$, $H^+$, $O_2$ etc.

**Oxidation & Synthesis**

\[
\begin{align*}
(A) & \quad COHNS + O_2 + NUTRIENTS \quad \rightarrow \quad CO_2 + NH_3 + C_3H_7O_2 + \text{other end products} \\
A & = \text{Bacterium} \\
B & = \text{New Bacterial Cells}
\end{align*}
\]

Biological aerated filter requires a constant rate of process air to maintain biomass activity. The aerobic environment in the grease trap is achieved by the use of diffused aeration @ 200L/hr.

**1.5.2 Biofilms**

Certain bacteria can attach to a surface and differentiate to form a complex, multicellular structure called a biofilm. A biofilm consists of microbial cells (algal, fungal, bacterial) and the extracellular biopolymer these cells produce. Bacteria attach to the surface by proteinaceous appendages referred to as fimbriae. Once a number of fimbriae have “glued” to the cell surface, the detachment of the organism becomes very difficult. Once attached, the organisms begin to produce material (an extracellular biopolymer called “slime” for short. The slime consists primarily of polysaccarides and water. The biofilm does is not simply a thick layer of extracellular material. There are channels and pathways that provide access to the interior portions of the biofilm. Overall the biofilm provides a favourable environment for the survival of the cells of the organism.
As the filter matures, the film becomes colonised by higher organisms such as protozoa, netatode worms and rotifers which feed on the bacteria, thus establishing food chains. A mature biofilm comprises of an outer layer which is largely fungi, a middle layer of fungi and algae and an inner layer of bacteria, fungi and algae. (CIWEM, 2000)

Fig 1.4: Formation of the Biofilm
During its passage down the filter, organic material in the wastewater together with oxygen and nutrients will diffuse into the biofilm and be oxidised by the heterotrophic microorganisms. The amount of organic material and oxygen available for microbial growth will depend on the film thickness and the organic load to the filter.

1.5.3 Biological Filters and Biological Concentrate

- Biological Filters
Biological Aerated Filter Systems are aerated systems based on fixed films or microbial cultures growing on a solid matrix of carrier material, thus reducing the loss of active culture due to dilution by flow rates.

Biological Filters are structured filter media that is an extremely efficient in the biological treatment of wastewater. The biological filter products used are made from environmentally friendly material polyethylene and consist of net tubes which are welded together to form a square block. The unique surface structure of the many net tubes provides a large accessible surface area for enhanced biological growth on the filter media. The surface of the filter acts as a substrate for specialised bacterial strains, which in turn can treat and degrade a wide range of wastewater qualities. The treatment capacity of a biological filter basically depends on the quantity of bacteria that the filter can
sustain. In other words, the larger the surface area is the larger is the bacterial population. The suspended system keeps the waste and biomass in continuous and intimate contact.

Fig 1.5: Representative Picture of Biofilter

Important chemical properties of the plastic media include inertness to biological degradation, resistance to attack by traces of organic chemicals and resistance to degeneration by ultra-violet light or deformation by temperature change. Extended life tests have indicated the last two facts to be less significant than expected due to the protection offered by the biological film. Most manufacturers expect a 50 yr life for plastic media.

* Biological Concentrate

The biological concentrate is a specially formulated liquid microbial product custom designed to enhance the biodegradation of organic wastes in specific aerobic wastewater treatment.
**Technical Description**

The biological concentrate contains non-pathogenic naturally occurring micro-organisms which have been specially selected for their ability to produce lipase, cellulase, amylase and protease enzymes to degrade organic substrates, as well as nutrients, trace elements and minerals, which activate the growth of the introduced strains and revitalise the existing biomass. The product is in the liquid form and have not been genetically engineered. The concentrate is also biodegradable and so does not harm the environment.

**Experimental Objective**

An environmental analysis of effluent exiting grease traps located on site indicated that the quality of the liquid waste was found to exceed the environmental limits set down by the local authority. The objective of this project was to investigate the feasibility of the application of biological treatment with aeration to effect a decrease on the loading of the grease traps thus bringing the quality of the liquid waste parameters to within the specified limits.
2.0 Materials & Methods

2.1 Project Materials & Equipment

2.1.1 Materials

The materials used are outlined below:

<table>
<thead>
<tr>
<th>Tanks (20L Capacity)</th>
<th>Blender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration Pumps (200L/hr)</td>
<td>Balance</td>
</tr>
<tr>
<td>Wafer / Crème Samples</td>
<td>Sample Bottles</td>
</tr>
<tr>
<td>Caramel Samples</td>
<td>Pipette</td>
</tr>
<tr>
<td>Effluent Samples</td>
<td>Pipette Tips (0.2ml)</td>
</tr>
<tr>
<td>Biological Concentrate</td>
<td>Pestle &amp; Mortar</td>
</tr>
<tr>
<td>COD Vials (0-15000 ppm)</td>
<td>Glassrod</td>
</tr>
<tr>
<td>Buffer Solutions 7 &amp; 10</td>
<td>Graduated cylinder</td>
</tr>
<tr>
<td>Cooling Rack</td>
<td>Safety Glasses</td>
</tr>
<tr>
<td>Whatman Filter Paper (125mm)</td>
<td>Disposable Gloves</td>
</tr>
</tbody>
</table>

The equipment used are outlined below:

- COD Reactor, Hach.
- DR/2000 Direct Reading Spectrophotometer, Hach
- HD 8602 pH Meter, Delta Ohm
- STS 4 Electrode & Temperature Probe
- Vacuum Buchner Flask & Funnel
- Bellingham and Stanley RFM340 refractometer
- ISCO 6700 Autosampler

2.2 Initial Proposal

A proposal was made to determine the feasibility of the use of biological treatment and aeration of grease traps to effect a decrease on the loading while maintaining pH levels to within the specified range of 6-10. Laboratory investigations were undertaken to investigate the effect of various, including selected bacteria and environmental conditions, on loading and pH. A number of tank (20L) experiments
were set up by preparing effluent samples similar in concentration to that exiting the plant at sources into the various grease traps, of which there are nine in existence. Due to the variance of ingredients exiting as effluent, firstly samples of wafer/creme were examined, then samples of caramel in order to investigate the effect of the biological treatment and aeration on foodstuffs of different composition. An autosampler was also set on site to monitor the loading currently on two of the existing grease traps.

2.3 Experimental Design

- Effluent samples were prepared to a concentration level similar to that entering the grease traps on site.
- These effluent samples under a series of various treatments, to investigate the effect of Biological Aerated Filter treatment on effluent samples in decreasing the parameters of wastewater quality.
- The samples were initially left untreated for a period of 6 days, this was the time it took for the parameters to fall outside licencing limits.
- The Effluent samples were then subject to a series of treatments, each being with the same effluent standard prepared initially.
- Treatments were as follows, aeration, biological concentrate / non-aeration, biological concentrate / aeration and finally biological aerated filter treatment.
- Grease traps on site were autosampled to investigate the wastewater parameters in the existing grease traps.

2.4 Determination of Chemical Oxygen Demand By Hach COD Meter

2.4.1 Introduction

The COD test utilises potassium dichromate in boiling concentrated sulphuric acid (150°) in the presence of a silver catalyst. Under these conditions most of the carbon in the sample is oxidised to CO₂ and the H₂ present is oxidised to H₂O. At the same time dichromate is reduced to trivalent chromium. The more organic material present in the sample, the more dichromate will be reduced to chromium (N.J. Horan, 1991). After oxidation the amount of dichromate consumed is determined colorimetrically.
using the Hach DR 2000 Spectrophotometer and the result is expressed in mg/l COD, which represent the amount of organic matter present in the sample.

2.4.2 Procedure

- Effluent samples (500ml) were collected in sample bottles.
- The COD reactor was preheated to 150°C, ensuring the plastic shield was in place.
- The sample (500ml) was homogenised for at least 2 minutes using the Blender.
- The appropriate digestion reagent for the sample concentration range required was selected (0-15000ppm - High Range Plus).
- The cap of the digestion vial was removed holding the vial at a 45° away from the analyst.
- The sample (0.2ml) was pipetted into the vial in duplicate.
- The vial cap was replaced and sealed tightly, rinsed with deionised water and wiped clean with a paper towel.
- A blank was prepared as above substituting deionised water for the sample.
- The vials were carefully inverted 3-4 times to mix the solution and placed in the preheated COD reactor.
- The reactor switch was switched to Timer and the timer adjusted to 120 (2hrs).
- The vials were heated in the reactor for 2hrs.
- The reactor was allowed to cool to 100°C.
- The vials were removed from the reactor, inverted once and allowed to stand in the cooling rack to cool to room temperature (~20 minutes).

2.4.3 Analysis and Calculations

- The store program number 435 was entered for High Range (HR) to read mg/l COD.
- The machine was zeroed using the blank/zero vial.
- The COD content of the samples were read.
2.5 Determination of Suspended Solids By Vacuum Filtration.

2.5.1 Introduction
Water is capable of holding minute particles in suspension. These particles can be measured by the passage of a known volume of the sample through filter paper thus retaining the minute particles, and allowing their mass to be recorded.

2.5.2 Procedure

- Filter paper was dried in the oven (100°C) for one hour.
- The filter was allowed to cool in the desiccator for half an hour, and then weighed.
- The filtration system was set up.
- The sample (50ml) was passed through the system, when filtering was complete the filtrate was taken and passed through again.
- The filter paper was removed and placed in a clean metal dish in the oven for one hour.
- The filter paper was then allowed to cool in the desiccator for half an hour and reweighed.

2.5.3 Calculations
The following equation will give the Suspended Solids in mg/l

\[ SS = (A-B) \times \left( \frac{1000}{V} \right) \times 10^3 \]

Where
- \( A \) = Mass of the filter paper after filtration (mg)
- \( B \) = Mass of the filter paper before filtration
- \( V \) = Volume of the sample (ml)
2.6 Determination of pH using pH Meter

2.6.1 Introduction

The principle of electrometric pH measurement is determination of the activity of the hydrogen ions by measurement using a standard hydrogen electrode and a reference electrode. The hydrogen electrode consists of a platinum electrode across which hydrogen gas is bubbled at a pressure of 101kPa. Because of difficulty in its use and the potential for poisoning the hydrogen electrode, the glass electrode commonly is used. The electromotive force (emf) produced in the glass electrode system varies linearly with pH. This linear relationship is described by plotting the measured emf against the pH of different buffers. Sample pH is determined by extrapolation. Because single ion activities such as $a_{H^+}$ cannot be measured, pH is defined operationally on a potentiometric scale. The pH measuring instrument is calibrated potentiometrically with an indicating (glass) electrode and a reference electrode using National Institute of Standards and Technology (NIST) buffers having assigned values so that:

$$pH_B = - \log_{10} a_{H^+}$$

2.6.2 Procedure

Calibration

- The pH electrode and temperature electrode were attached to the 8602 unit and the electrodes immersed and stirred in a buffer solution of pH = 7.00 ensuring it is wet.

- The °C button was pressed and the temperature read. To proceed to calibration mode, the pH button was pressed and then the ‘CAL’ button (Δ symbol appears on the display and the ph symbol flashes.

- Using the arrow keys ▲ and ▼ the display indicated the pH value of the buffer selected (10.00). The ‘Cal’ button was pressed and the pH symbol stops flashing and the Δ disappears.

- The electrodes were removed and carefully rinsed and dried with tissue paper.
2.6.3 Analysis

- The sample was taken and divided into two parts, using one part to wash the electrodes prior to analysis.
- The electrodes were washed in distilled water and then immersed the pH and temperature electrodes were immersed in the solution to be analysed.
- The pH button was pressed and the electrodes gently stirred in the solution to be analysed thus giving the pH of the solution under analysis.
- The electrodes were removed, rinsed in distilled water prior to replacing them in their protective cases.
- The values obtained on duplicate determinations performed in immediate succession should be within +/- 0.5 pH units.

2.7 Determination of Biochemical Oxygen Demand by Dilution Method

2.7.1 Introduction

The Biochemical Oxygen Demand (BOD) is an empirical test which standardised laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents and polluted waters. This test exploits the ability of microorganisms to oxidise organic matter to carbon dioxide and water using molecular oxidising agent. The method used for the determination of BOD
measurement is the dilution method. The relationship of oxygen that was consumed in the 5 days and the volume of the sample increment is then used to calculate the BOD.

2.7.2 Procedure

- The required BOD Nutrient Buffer Pillow was selected, shaken, cut open, and the contents added to a jug containing the required amount of distilled water at 20°C.

- The jug was capped and shaken vigorously for 1 minute to dissolve the slurry and to saturate the water with oxygen.

- Using a serological pipet, a graduated series of at least four, but preferably five or six, portions of well mixed sample were measured and added to BOD bottles. The sample was stirred well with the pipette before pipetting each sample.

- Two measurements of Nitrification Inhibitor (0.16g) were added from the dispenser bottle to the BOD bottle.

- Each BOD bottle was filled just below the lip with seeded dilution solution. In order to prevent the formation of bubbles the water was allowed to flow slowly down the sides of the bottle.

- The bottle was stoppered, taking care not to trap any air bubbles, and the bottle was inverted several times. Enough dilution water was added to cover the lip of the BOD bottle to make a water seal.

- A plastic cap was placed over the lip of each BOD bottle and the bottles were placed in the dark for 5 days at 20°C ± 1°C.

- After the 5-day incubation period was complete, the dissolved oxygen of each of the samples was determined.
2.8 Determination of Oils, Fats and Greases.

2.8.1 Introduction

In the determination of oil and grease, an absolute quantity of a specific substance is not measured. Rather, groups of substances with similar physical characteristics are determined quantitatively on the basis of their common solubility in an organic extracting solvent.

2.8.2 Procedure


2.9 Determination of Total Solids using Bellingham and Stanley RFM

2.9.1 Introduction

The % dissolved sugars were determined by the principle of refractometry

2.9.2 Procedure

- The refractometer and recirculatory water bath was turned on for a half an hour before use to allow the water jacketed prism to reach the correct temperature. The prism surface was cleaned thoroughly.

- The instrument scale was set on BX (Brix). This was done by pressing MODE, entering the password 043 and selecting scale once and then press QUIT.

- The sample was applied to the prism making sure to remove it from the centre (width and depthwise) of the container to eliminate edge effects.

- Using a disposable pipette a sample was applied to the surface of the prism ensuring that the entire surface was covered. The presser was lowered and the sample was allowed to equilibrate with the refractometer (this can take up to ~20 mins.)
To read samples, press enter, and continue to read until the reading remains constant for at least 43 consecutive readings. The result was recorded.

2.10 Sample Collection by ISCO 6700 Autosampler

2.10.1 Procedure

- The sampler was turned on, and the option ‘program’ was selected, return was pressed. Site description was entered then press ↓

- The units for length were selected as metres (m). A composite sample was required and so no of bottles selected was one, then press ↓

- Bottle volume selected was 10L, then press ↓

- Suction line length of 5m was selected, then press ↓

- Auto section was selected and return pressed. One rinse cycle was selected , then press ↓

- One part program was selected and uniform time paced selected, then press ↓

- A time of 30 mins was selected as time between samples and the programme to run continuously, then press ↓

- Samples to be taken :150 samples, samples dependent on flow, sample volume : 50ml, then press ↓

- The system was enabled and selection that once enabled to stay enabled was selected . Once programme is complete, select ‘YES’ for run programme.

- Samples were collected after programme run and analysed for suspended solids and Refractive Index.
3.0 Experiments & Results

3.1.1 Effect of various treatment on wastewater quality parameters.

Two effluent samples, similar in concentration to that entering the grease traps on site one containing Timeout wafer and crème and the other caramel were analysed after a period of 6 days after various treatment listed below as A,B,C,D,E for the effect on the water quality parameters.

A : Non-Biological Treatment / Non-Aeration
B : Aeration
C : Concentrate / Non-Aeration
D : Concentrate / Aeration
E : Concentrate / Biofilter /Aeration

3.1.2 Result of the Effect of Treatments A, B, C, D & E on pH value.

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Creme</td>
<td>4.34</td>
<td>5.60</td>
<td>4.89</td>
<td>5.37</td>
<td>6.72</td>
</tr>
<tr>
<td>Caramel</td>
<td>4.44</td>
<td>5.10</td>
<td>4.35</td>
<td>4.77</td>
<td>6.54</td>
</tr>
</tbody>
</table>

Table 3.1 Result of the Effect of Treatments on pH value.

Fig 3.1 Effect of Treatments A, B, C, D & E on pH value
Comments:
(a) Biological aerated filter treatment of the wafer/crème effluent sample showed a 54% increase in the pH, thus bringing the pH level to within the specified range of 6-10.
(b) Biological aerated filter treatment of the caramel effluent sample showed a 47% increase in the pH also bringing the pH value within the specified range of 6-10.
(c) Treatment by A, B, C and D failed to elevate the pH levels of both effluent samples to within the limit of 6-10.

3.1.3 Result of the Effect of Treatments A, B, C, D & E on BOD.

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Creme</td>
<td>3611</td>
<td>1480</td>
<td>1248</td>
<td>1184</td>
<td>947</td>
</tr>
<tr>
<td>Caramel</td>
<td>4662</td>
<td>1954</td>
<td>1854</td>
<td>1729</td>
<td>654</td>
</tr>
</tbody>
</table>

Table 3.2 Result of the Effect of Treatments on BOD

![Fig 3.2 Effect of Treatments A, B, C, D & E on BOD](image-url)
Comments:
(a) Biological aerated filter treatment of wafer/crème effluent sample showed a 73% decrease in the BOD level.
(b) Biological aerated filter treatment of caramel effluent sample showed a 85% decrease in the BOD level.
(c) Biological aerated treatment showed an optimum decrease in BOD when compared to treatment by A, B, C & D.

3.1.4 Result of the Effect of Treatments A, B, C, D & E on COD.

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Creme</td>
<td>7240</td>
<td>5850</td>
<td>6568</td>
<td>6158</td>
<td>6015</td>
</tr>
<tr>
<td>Caramel</td>
<td>8605</td>
<td>5665</td>
<td>5940</td>
<td>5472</td>
<td>5220</td>
</tr>
</tbody>
</table>

Table 3.3 Result of the Effect of Treatments on COD

Effect of Treatments A,B,C,D & E on COD

Fig 3.3 Effect of Treatments A, B, C, D & E on COD
Comments:
(a) Biological aerated treatment of wafer/creme effluent sample showed a 17% decrease in COD levels.
(b) Biological aerated filter treatment of caramel effluent sample showed a 40% decrease in COD levels.
(c) Overall treatment by biological aerated filter gives an optimum decrease in COD levels as compared to treatment by A, B, C & D.

3.1.5 Result of the Effect of Treatments A, B, C, D & E on Suspended Solids

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Creme</td>
<td>1400</td>
<td>860</td>
<td>640</td>
<td>600</td>
<td>620</td>
</tr>
<tr>
<td>Caramel</td>
<td>800</td>
<td>460</td>
<td>600</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

Table 3.4 Result of the Effect of Treatments on Suspended Solids

Fig 3.4 Effect of Treatments A, B, C, D & E on Suspended Solids
Comments:
(a) Biological aerated filter treatment of the wafer/crème effluent sample showed
55% decrease in the levels of suspended solids.
(b) Biological aerated treatment of the caramel effluent sample showed a 50%
decrease in the levels of suspended solids.

3.1.6 Result of the Effect of Treatment A, B, C, D & E on Oils, Fats & Grease

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Crème</td>
<td>1864</td>
<td>529</td>
<td>484</td>
<td>359</td>
<td>580</td>
</tr>
<tr>
<td>Caramel</td>
<td>615</td>
<td>397</td>
<td>356</td>
<td>298</td>
<td>487</td>
</tr>
</tbody>
</table>

Table 3.5 Result of the Effect of Treatments on OFG

Fig 3.5 Effect on Treatment A, B, C, D & E on Oils, Fats & Grease
Comment:
(a) Biological aerated filter treatment of the wafer/crème effluent sample showed a 68% decrease in the levels of oils, fats & greases, bringing the level below the specified limit of 600 ppm.
(b) Biological aerated filter treatment of the caramel effluent sample shows a 20% decrease in the level of oils, fats & greases.

3.1.7 Result of the Effect of Treatment A, B, C, D & E on Refractive Index

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer/Creme</td>
<td>0.39</td>
<td>0.38</td>
<td>0.37</td>
<td>0.61</td>
<td>0.21</td>
</tr>
<tr>
<td>Caramel</td>
<td>0.68</td>
<td>0.35</td>
<td>0.30</td>
<td>0.47</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Table 3.6 Result of the Effect of Treatments on Ref. Index

Fig 3.6 Effect of Treatments A, B, C, D & E on Refractive Index

Comments:
(a) Biological aerated filter treatment of the wafer/crème effluent sample showed a 46% decrease in the refractive index reading.
(b) Biological aerated filter treatment of the caramel effluent sample showed a 59% decrease in the refractive index reading.
3.1.8 Effect of Biological Aerated Filter on pH levels

pH levels were monitored daily over a period of 6 days, the following was observed:

- There is evidence of a drop in pH during the biological stage of treatment due to the oxidation of organic matter and the production of CO₂.

3.1.9 Result of the Analysis of the Eclairs grease trap

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (m²/day)</th>
<th>S. Solids Ppm</th>
<th>Ref. Index % Sugar</th>
<th>S. Solids kg/day</th>
<th>Sugars kg/day</th>
<th>Totals kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/11/01</td>
<td>21.91</td>
<td>5620</td>
<td>1.3</td>
<td>123.13</td>
<td>284.83</td>
<td>407.96</td>
</tr>
<tr>
<td>11/11/01</td>
<td>37.13</td>
<td>3050</td>
<td>0.87</td>
<td>113.25</td>
<td>323.03</td>
<td>436.28</td>
</tr>
<tr>
<td>12/11/01</td>
<td>14.5</td>
<td>4520</td>
<td>1.1</td>
<td>65.54</td>
<td>159.50</td>
<td>225.04</td>
</tr>
<tr>
<td>13/11/01</td>
<td>17.34</td>
<td>6338</td>
<td>1.2</td>
<td>109.90</td>
<td>208.08</td>
<td>317.98</td>
</tr>
<tr>
<td>14/11/01</td>
<td>17.5</td>
<td>6260</td>
<td>1.3</td>
<td>109.55</td>
<td>227.50</td>
<td>337.05</td>
</tr>
<tr>
<td>Total</td>
<td>108.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Ingredients Loss from Eclairs over 5 days | 1724.34 kg

Table 3.7 Results of the analysis of the Eclairs grease trap
3.1.10 Result of the Analysis of the Timeout grease trap

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (m$^3$/day)</th>
<th>S. Solids Ppm</th>
<th>Ref. Index % Sugar</th>
<th>S. Solids kg/day</th>
<th>Sugars kg/day</th>
<th>Totals kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/11/01</td>
<td>12.15</td>
<td></td>
<td>0.23</td>
<td>0.00</td>
<td>27.95</td>
<td>27.95</td>
</tr>
<tr>
<td>11/11/01</td>
<td>30.2</td>
<td></td>
<td>0.9</td>
<td>0.00</td>
<td>271.50</td>
<td>271.80</td>
</tr>
<tr>
<td>12/11/01</td>
<td>25.7</td>
<td>3038</td>
<td>0.85</td>
<td>78.08</td>
<td>218.45</td>
<td>296.53</td>
</tr>
<tr>
<td>13/11/01</td>
<td>18.6</td>
<td></td>
<td>0.34</td>
<td>0.00</td>
<td>63.24</td>
<td>63.24</td>
</tr>
<tr>
<td>14/11/01</td>
<td>18.3</td>
<td>1600</td>
<td>0.24</td>
<td>29.28</td>
<td>43.92</td>
<td>73.20</td>
</tr>
<tr>
<td>Total</td>
<td>104.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Ingredients Loss from Timeout over 5 days: 733 kg

Table 3.8 Result of the analysis of the Timeout grease trap

3.1.11 Determination of the decrease on the total suspended solids present due to Biological Aerated Filter Treatment.

- A flow rate of 1 m$^3$/day was assumed in the case of the prepared Eclairs effluent sample:

<table>
<thead>
<tr>
<th></th>
<th>Flow (m$^3$/day)</th>
<th>S. Solids Ppm</th>
<th>Ref. Index % Sugar</th>
<th>S. Solids Kg/day</th>
<th>Sugars Kg/day</th>
<th>Totals Kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-biological Treatment</td>
<td>1 m$^3$</td>
<td>800</td>
<td>0.68</td>
<td>0.8</td>
<td>6.8</td>
<td>7.6</td>
</tr>
<tr>
<td>Post- biological Treatment</td>
<td>1 m$^3$</td>
<td>400</td>
<td>0.28</td>
<td>0.4</td>
<td>2.8</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table 3.9 Result of decrease on the total suspended solids present due to BAF

- From the above laboratory results of Eclairs effluent pre & post treatment there can be seen a 57% decrease in the total suspended solids present.
A flow rate of 1 m³/day was assumed in the case of the prepared wafer /crème effluent sample.

<table>
<thead>
<tr>
<th></th>
<th>Flow (m³/day)</th>
<th>S. Solids Ppm</th>
<th>Ref. Index % Sugar</th>
<th>S. Solids kg/day</th>
<th>Sugars kg/day</th>
<th>Totals kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-biological Treatment</td>
<td>1m³</td>
<td>1400</td>
<td>0.28</td>
<td>1.4</td>
<td>2.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Post-biological Treatment</td>
<td>1m³</td>
<td>620</td>
<td>0.21</td>
<td>0.6</td>
<td>2.1</td>
<td>2.7</td>
</tr>
</tbody>
</table>

From the above laboratory results of Eclairs effluent pre & post treatment there can be seen a 35 % decrease on the total suspended solids present.

By assuming the experimental flow rate of both laboratory effluent samples as 1 m³, one can predict the percentage drop in total suspended solids due to biological treatment on a larger scale when the flow rates are known.

Calculations:
By estimating a 57% decrease in the loading of the wafer /crème effluent sample, one could predict the ideal situation on the larger scale of a decrease from 733 kg to 417.81 kg on the loading of the grease traps in the period of a week.
By estimating a 35% decrease in the loading of the Eclairs effluent sample, one could predict the ideal situation on the larger scale a decrease from 1724 kg to 603 kg on the loading of the grease traps in the period of the week.

Note: It must be taken into account that the retention times allowed in the grease traps on site are incapable of retaining large volumes for a period of 5-6 days.
4.0 DISCUSSION

4.1 Introduction

This project set out to examine the effect of biological treatment with aeration on the quality of wastewater. The overall quality of wastewater depends on the water quality parameters: BOD, COD, SS, OFG and pH. Laboratory experiments were carried out to determine the feasibility and effectiveness of the biological aerated filter system in maintaining these wastewater parameters within the licencing limits.

The biological aerated filter was shown to bring the wastewater quality parameters of the standard effluent samples to within the specified licencing limits, although the residence time required for such an effect to reach these specifications was outside that of the residence times available in the grease traps on site.

4.2 Industrial Effluent

Wastewater effluent represents an extremely complex mixture of organic (sugars, carbohydrates, proteins, etc) and inorganic material (packaging).

4.2.1 Biological Aerated Filter Treatment

Standard effluent samples were prepared and treated biologically by biological aerated filtration. The parameters of the wastewater investigated included BOD, COD, SS, OFG & pH. The standard effluent samples were also subject to analysis under the following conditions:

- A - biological treatment absent / aeration absent
- B - aeration
- C - biological concentrate / non-aeration
- D - biological concentrate / aeration
- E - biological concentrate / biofilter / aeration

The resulting analysis showed that treatment by biological aerated filtration alone was successful in bringing the parameters within the specifications of the licencing limits. The treatment showed a decrease of 68% in levels of OFG in case of wafer / crème effluent sample thus bringing the level below the specified limit 600ppm. This is largely significant as the disposal of OFG is becoming largely restrictive and costly.
4.3 Effect of Non-Biological Treatment and Non-Aeration on the wastewater quality parameters.

The sample effluents were allowed to stand without any biological treatment or aeration. After a period of 6 days the waste water parameters were examined. In the case of each parameter (Ph, BOD, COD, OFG, SS) it was found that they all exceeded the licencing limit. The time it took the effluent samples to exceed the limits was ~6 days. This residence time was used as a standard, which was used in the application of the other treatments to the effluent.

4.4 Effect of Biological Aerated Filter Treatment on pH over 6 days

Biological activity and aeration caused a pH rise to within specification, due to specially formulated biological concentrate incorporating bacterial cultures and selected nutrients.

Generally, the pH begins to drop at the initiation of the biological process. This is a consequence of the activity of the acid-forming bacteria whoch break down complex carbonaceous material to organic acid intermediates. A part of the acid formation may take place in localised anaerobic zones. A part may be due to conditions of abundances of carbonaceous substrate and resulting accumulation of intermediates formed by shunt metabolism arising from the metabolism arising form the abundance and perhaps from interfering environmental conditions. Regardless of the causes, the pH level may drop to as low as 4.5 to 5.0. While microbial activity may be inhibited somewhat, the effect is only transitory. Fortunately, the synthesis of organic acid is accompanied by the development of a population of microorganisms capable of utilising the acids as a substrate. The net effect is that after a few days in a rapid-type biological process the pH begins to rise. The pH continues to rise until a level of 8.0 to 9.0 and the mass becomes alkaline. (Gonlueke, 1997)
The pH of the effluent samples was found to significantly influence the effect of the biological treatment by BAF. It can be seen that a pH over 6 gives the optimum decrease in BOD and suspended solids. Thus this enforces the fact that the pH of the environment is a key factor in the growth of organisms. Most bacteria cannot tolerate pH levels above 9.5 and below 4.0. Generally the optimum pH for bacterial growth lies between 6.5 & 7.5. (Metcalf, pp366)

4.5 Effect of Aeration Versus Non-Aeration on The Biological System

Aeration of the samples was found to stimulate biological activity which optimises the degradation of organic matter while maintaining a satisfactory pH. This is evident on comparing the results of the biological concentrate with and without aeration. Overall there was a higher performance of the concentrate in the presence of sufficient oxygen. The aerated biological filter performed the best overall due to the presence of aeration and the existence of the biomass (filter film).

4.6 Filter Media & Biofilm

Essential requirements for filter medium are, inert, sound mechanical strength, possesses within its bulk an exposed surfaces over which liquid can be passed. It has adequate void spaces existing between adjacent surfaces to allow for accumulation of biological film, for the passage of liquid and suspended matter and the access of air.

The large voidage and predominately vertical orientation of surfaces of the plastic media discourage the development of thick film layers, thus permitting unrestricted flow of liquid over the medium surface. (T. J Casey, 1996)

The biological film or slime layer is inhabited by an independent microbial population, including bacteria, fungi and protozoa. The efficiency of the process is ultimately dependent upon the metabolic activities of the microbial population in the filter film. These organisms enzymically hydrolyse polymeric material, such as protein, fats and carbohydrates into their constituent monomers. Consequently these monomers may be metabolised in the presence of oxygen to result in the production of natural inorganic substances.
4.7 Limitation Factors of Biological Aerated Filtration in the Grease Traps

Emphasis must be put on the fact of the certain limitations that exist as a result of the laboratory findings:

- **Residence Time**

  The Residence Time (RT), the time that the waste spends in the treatment reservoir, depends on the volume and the flow rate through the reservoir. Due to the relatively small grease trap volume and the high influent rates the resident time. The laboratory study revealed a certain start up period before optimal biological activity occurred.

- **Fluctuations in flow rates**

  Fluctuations in flow rates may have serious implications on the efficiency of the biological treatment in the grease trap. To optimise the treatability the residence times must be increased. With the possibility of increased residence times by the further development of large retention treatment vessels on site, the possibility of fluctuations in flow rates is a factor that must be addressed so as not to permit a hinderence on the treatment system. On days of low flow rate effective treatment might be obtained, but on days when the flow rates are high treatment would be at best incomplete and there would be a strong probability of the effluent pH being below the licence limit.

- **The low initial pH and pH variations due to caustic washes**

  Wide fluctuations in the pH of the waste stream due to caustic wastes and low initial pH of the waste are known to inactivate biological systems through pH shock. In most biological treatment plants it is regarded as standard procedure procedure to control the pH between 6.0 to 8.5. Balancing of the wastewater before treatment may achieve the desired result. Also, if left untreated, the low initial pH of the waste would contribute to the necessity for longer residence times in any grease trap biological aerated filter system.
4.8 Recommended Future Work

There are a number of measures which could be considered in order to alleviate the problems associated with retention times & pH levels.

Installation of large retention tanks on site as a means of overcoming the problem of short residence times and large volumes.

- The installation of a chemical pH control meter, acid & alkali resevoir could be fed to each grease trap via pumps controlled by an electronic signal from a pH meter. Caustic washes could possibly be diverted to a separate resevoir and the pH adjusted to 6-10 therefore optimising conditions for biological treatment.

- Consideration should be given to the feasibility of standardising the flow rates to the grease traps in order to restandardise residence times. Diversion of caustic washes would also facilitate this process in addition to raising the pH.

- An evaluation on where the sources of waste on site are that are contributing to the high loads on the grease traps. Some of the sources are:
  - Rinsewater and washwater from CIP systems used to wash tanks, equipment, product pipelines and floors.
  - Spillage and leakage caused by improperly maintained equipment and poor operating practices. Spillage is a result of careless handling or improper design of layout of equipment. This loss occurs primarily where product is dumped from one vessel to another.
  - Loss of leakage can be prevented by care in assembly of equipment, and by proper maintenance. When a leak occurs during operation a container should be available to prevent it reaching the sewer.
  - Packaging
5. CONCLUSION

Biological Aerated Treatment of effluent samples showed a significant effect on the bringing of the wastewaters parameters within the required specification while also decreasing the loading in the sample. However, this experiment was done on a laboratory scale, and it is advised that very close monitoring of its application on the actual large scale grease trap be carried out.

The results of the project point to the fact that longer residence times may be required therefore larger scale treatment facilities may be something to be considered for the future. This strategy will demand careful design, planning, experimentation and monitoring as well as flexibility with regard to production operations in order to increase the chances of success.
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