THE QUALITY EVALUATION OF TREATED EFFLUENT BEFORE DISCHARGE

(A CASE STUDY OF THE KADUNA REFINING AND PETROCHEMICAL COMPANY)

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A FINAL YEAR PROJECT WORK PRESENTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR AN AWARD OF BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN CHEMICAL ENGINEERING OF THE FEDERAL UNIVERSITY OF TECHNOLOGY MINNA NIGER STATE, NIGERIA

OCTOBER 2003

DECLARATION

I **ONI OLATUNDE RAZAQ** with Matric Number **98/7748EH** of the Department of Chemical Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna hereby declare that the research work is submitted in partial fulfilment of the award of B. Eng of the Federal University of Technology, Minna and that it is solely my work and effort. All references extracted from published and unpublished work are acknowledged in my write up.

ONI OLATUNDE RAZAQ		20/10/2003
Name of student	Signature of Student	Date

DEDICATION

This project is dedicated to first and foremost ALLAH, whose name is above all names. The sovereign, the lord of the worlds, to whom I dedicate my prayer, my sacrifice, my entire life and my death. In whom is my hope and unto whom I turn in repentance for His guidance, mercy, protection, blessings and above all things paradise. Amin.

Secondly my loving parents, the most wonderful parents on earth Alhaji and Alhaja W. B. Oni. All my siblings for their untiring and invaluable support towards my continuing academic pursuit in life. May Allah almighty reward them all with paradise. Amin

Thirdly, my sweet cousin late Rasheedat Bamigbaiye. May Allah bless her soul and reward her with paradise. Amin.

Finally to all the wonderful people that admire the value of good education.

CERTIFICATION

This research work – The quality evaluation of treated effluent before discharge (a case study of the Kaduna refining and petrochemical company) by ONI OLATUNDE RAZAQ, 98/7748EH has been read and approved by my supervisor as partial fulfilment of the requirement for the award of Bachelor of Engineering (B.Eng.) degree in Chemical Engineering of the Federal University of Technology, Minna - Niger State, Nigeria.

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ACKNOWLEDGEMENTS

My most profound and heart felt gratitude goes to the Almighty Allah for giving me the strength spiritually, physically and mentally to have come this close to success. All praises and thanks are due to Him.

My sincere appreciation also goes to my parents, Alhaji and Alhaja W. B. Oni, for mere words cannot express how fulfilling and joyful it is to have you both as my father and mother. To all my siblings in persons of Alhaji Abdulquadri Oni, Mr. Mohammed Oni, Alhaji Tajudeen Oni, Mr. Ahmed Oni, Mrs. Adebarjo, Mrs. Abiodun Adeyinka, Sister Lateefat and Sister Fatima.

My most sincere appreciation also goes to my wonderful supervisor in person of Engr. Abdulazeez .You are such a wonderful person and may almighty Allah reward you abundantly, may He also bless you with paradise. Amin

My heart felt thanks also goes to my wonderful uncle Alhaji A.O Fadipe, his wife and children. May Allah reward all of you with paradise. Amin.

My appreciation also goes to Papa and Mama Ajayi.Thank you for fatherly and motherly advice.

There are special people in our lives whose encouragement and assistance push us closer to our dreams and goals in life. My warmest gratitude goes to those people, my big brother Tajudeen Oni, my father Alhaji Oni, and my beloved mother Alhaja Oni. To all my friends in persons of Ogunlabi Olasunkanmi, Suleiman Alfa, Moshood Hassan, Opeoluwa Olufeko, Akin Akinremi, Emeka Igbosua and Andrew Ajayi. It feels wonderful to know that I have true friends in you guys.

ABSTRACT

Aqueous wastewater (liquid effluent) is the most significant discharge to the environment generated by petroleum refineries. Kaduna refining and Petrochemical Company is not an exception. Experiments were carried out on the effluent generated to investigate whether it meets the FEPA standard for effluent limitations. The analysis was carried out on four different samples for four different weeks. The parameters checked are temperature, PH, turbidity, conductivity, chemical oxygen demand, Biochemical oxygen demand, hardness, solids, phenol content, phosphate content. All met the FEPA requirements except turbidity, which was above the FEPA allowable limit. Conclusions were drawn and recommendations were also made on how to improve on the quality of effluent discharged by the company.

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CHAPTER ONE

1.0 INTRODUCTION.

The increasing energy demand over the past years has resulted in the corresponding growth and expansion in the refining and processing of crude petroleum. The establishment of refineries around the country combined with the facilities has underscored the need for perfecting existing pollution control technology.

A petroleum refinery comprises of many interrelated processes that generally separate water and rebuild the crude molecular configuration into desired products. Although the ideal method in controlling petroleum refinery effluent water discharge is to eliminate them at the source, process modification and in plant control practices are often rendered. Therefore chemical, physical and biological treatment processes must be properly utilized to effectively remove the critical pollutants contained within these effluents. The treatment and control of refinery effluent is primarily to minimize and / or to remove certain waste materials so as to eliminate or minimize to a great extent the possibilities of harmful effects on the receiving environment caused by the toxic substances contain in the effluent. It therefore becomes most apparent that a programme must be designed to measure quantitatively and qualitatively for the purpose of detecting and eliminating these toxic substances over a period of time.
Quality evaluation could therefore be carried out based on the control of wastewater, which could be in two aspects.

1. Control for (technology) process efficiency, which is primarily the responsibility of process plant engineers and operators.
2. Control with the help of public officials / chemical analysis to make sure that the plant is operating efficiently so much that all the discharge (effluent) satisfy the allowable limits and quality control standards as set by the equipment manufactures and regulating agencies. This project concerns mainly the latter aspect.

1.1 THE NEED FOR EFFLUENT TREATMENT BEFORE DISCHARGE

Considering the various processes undergone by the effluent water in the process plants, sanitary departments, cooling towers before being collected into the wastewater treatment unit, it is therefore associated with numerous contaminants. These contaminants are contained in different concentrations and should not be allowed to exceed certain allowable limits. This if not taken care of can consequently lead to pollution and affect the lives of aquatics, birds and other inhabitants of the receiving environment. These contaminants such as phosphate, phenol, temperature, ph, BOD, COD etc. can lead to pollution, if not properly monitored.

Below is the summary of the adverse effects of these contaminants on the environment if not properly monitored.

Temperature is a very important parameter in the lives of living organisms because extremes of temperature could have adverse affects on the environment. Effluent heat loads (high temperature effluents) cause decreased oxygen solubility and greater oxygen utilization, both which reduce the ability of the stream (water) to handle waste loads thereby killing the organisms in it.

PH is the reliable indication of the acidic or alkaline tendency of the effluent. It is an important consideration in determining the corrosive action of water (effluent). If acidic, has an adverse effect on the receiving body.

Turbidity in effluent is caused by the presence of suspended and dissolved particles of gas, liquid or solids of organic or inorganic matter. It is extremely undesirable in effluent waters, dinking water e.t.c. The measurement of turbidity provides a rapid means of process control for when, how and to what extent the waste water must be treated to meet the design specifications.

Hardness in water and waste water (effluent) notably calcium and magnesium are the primary cause of tube and pipe scaling which frequently causes failures and loss of process efficiency due to clogging or loss of heat transfer or both. It also Causes wastage of soap because hard water possess soap wasting properties.

Chemical oxygen demand is the amount of oxygen required under specified conditions for the oxidization of water borne organic and inorganic matter.

The measurement of COD is used to monitor and control oxygen consuming pollutants, both inorganic and organic in domestic and industrial effluents.

Biological oxygen demand, which involves dissolved oxygen, is required for the survival and growth of many aquatic organisms including fish. The concentration of dissolved oxygen may be associated with corrosive and photosynthetic activity. The absence of oxygen may permit anaerobic decay of organic matter and the production of toxic and undesirable esthetic materials in water e.t.c.

Data on the composition and characteristics of treated effluent are frequently used to evaluate the health and safety of humans, birds, aquatics and other organisms-that use such treated effluent receiving bodies for various purposes. These data are frequently used to ascertain compliance with regulatory bodies that place limits on acceptable composition and characteristics of the effluent waters.

Therefore the need to treat, control and evaluate the quality of effluent water is highly essential and should not be underestimated even in its smallest measurement.

1.2 BRIEF INTRODUCTION, GUIDELINES AND STANDARDS FOR INDUSTRIAL EFFLUENT (REFINERY EFFLUENT)

Industrialization is vital to a nations socio-economic development as well as its political stature in the international committee of nations. It provides ready employment opportunities for a good percentage of the population in medium to highly developed economies. However industries vary according to process technology, size, and nature of products, characteristics and complexity of waste discharged. In the case of this project, the oil industry (petroleum refinery) is being put into consideration.

Ideally, sitting of oil refineries should strike a balance between socio-economic and environmental considerations. Availability and access to raw materials proximity of water resources, effective transportation route e.t.c often influence the sitting of these industries. In Nigeria sitting of oil industries is determined by various criteria, some of which are environmentally unacceptable thereby posing serious threat to public health.

Economic development can be compatible with environmental conservation. Hence the present problems of environmental resources degradation need not arise within the framework of sustainable development. Failure to halt further deterioration of environmental quality might jeopardize the health of larger segment of the population with serious political and socio-economic implications.

The federal military government placed high premium on the environment. It established the federal Environmental Protection Agency (FEPA) by decree 58 of 30th December 1988 with the statutory responsibility for overall protection of the environment. The national environmental policy was put together and launched by the president in Abuja on 27th November 1980. Logically, implementation of the policy should follow. Introducing the guidelines and standards is part of the implementation of the policy and environmental pollution abatement strategy contained therein. These standards and guidelines relate to six areas of environmental pollution control but we are only looking at one of them, which specifically relates to this research project, which is effluent limitations.

1.3 SCOPE AND OBJECTIVE.

The Kaduna refining and petrochemical company was used as a case study. Treatment of effluent water like oily wastewater, process, and sanitary wastewater, clean wastewater were examined and studied extensively.

Treated effluent samples were collected from the wastewater treatment plant for quality evaluation towards knowing whether the effluent to be discharged to the receiving bodies is free from toxic substances.

The results of the evaluation will be compared with the N.N.P.C./ FEPA design standards and specification to know whether the plant is operating efficiently to an extent that all the effluent satisfy the allowable limits and quality control standards as set by the equipment manufactures and regulating bodies (agencies).

The parameters considered are listed below.

a. Temperature. b. Ph c. Turbidity. d. Conductivity .e. Alkalinity (methyl and phenolphthalein) .f. Chemical oxygen demand (COD) .g. Biological oxygen demand

(BOD) .h. Phosphate content i. Phenol content .j. Hardness (total, calcium and magnesium hardness) .k. Solids.

The objective of this project is to primarily have the general knowledge of the characterization of effluent water, treatment of effluent (waste water treatment).
Generate results by carrying out chemical analysis on the parameter listed above. Compare the generated results with the standards to know whether the plant is discharging effluent of widely accepted quality and make recommendations towards improving on the quality of effluents and also building a more pollution free society at large.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water

Water is made up of hydrogen and oxygen atoms. A molecule of water is made up of two hydrogen atoms and an oxygen atom. The chemical symbol of hydrogen is H and that of oxygen is O. Therefore water is written chemically as H_2O. Water undergoes slight ionization giving H^+ and OH^- i.e. $H_2O \rightleftharpoons H^+ + OH^-$. Pure water is neutral because of equal number of hydrogen ions and that of hydroxyl ions.

The source of earth's water is its rainfall, this may be considered as the condensate in the purification system operated by Mother Nature and based on the distillation principle. This initially pure water passes through the atmosphere and collects or absorbs impurities. The type and quantity of impurities depends upon the nature of the atmosphere through which the rain passes. The principal impurities are oxides of sulfur, carbon (CO), nitrogen and carbon dioxide e.t.c. These impurities will depend upon the nature of the atmosphere. For example in or around a refinery the principal impurities of rain water will be oxides of sulfur, nitrogen, carbon, e.t.c depending on the emissions in the atmosphere. The presence of these impurities in water gives rise to most of the damage caused by corrosion.

Water is not stable; it can float from one place to another. When it moves over earth it carries along different impurities on land to its destination. Owing to this instability water contains many impurities causing hardness. Calcium, magnesium bicarbonates, sulphate ions and traces of other elements cause hardness of water. Hard water contains calcium and magnesium. Water hardness can be classified into permanent hardness and temporary hardness which are caused by the presence of sulphate of calcium and magnesium and cannot be removed by boiling and by the presence of hydrogen carbonate of magnesium and calcium and can be removed by boiling respectively.

2.2 Effluent Water

Effluent water originates from the water used in the process plant and other areas in the refineries. This water after passing through all these processing route is finally collected as wastewater in a unit called wastewater treatment unit for treatment before discharge into the receiving areas.

In order to meet the required standard as well as operate the unit economically and effectively, the wastewater is segregated into the following groups based on their contaminants.

group 1

These wastewaters contain high biochemical oxygen demand (BOD), chemical oxygen demand (COD), high hydrocarbon content, phenol and other organic matters.

a) Process oily waste water
b) Sanitary waste water
c) Boiler blow down
d) Laboratory waste

These come into the wastewater plant through the surface piping.

group 2

These wastewaters contain oily matter, suspended solids and low biochemical oxygen demand and chemical oxygen demand. This group comprises of

a) Pumps and compressors cooling water
b) Crude tank drains
c) Drainages from wastewater treatment unit.

group 3

All members of this group contain either acid or alkalis and some other chemicals; hence they are called chemical wastewater. The members of this group are:

a) Cooling tower blow down
b) Neutralized wastewater from the demineralizer

They come into the wastewater treatment unit through surface piping.

group 4

These are made up of

a). Rain water

b). Non- recovered condensate

c). Over flows and drains from filtered water tank (FWT) and rain water tanks (RWT). They do not contain any harmful matter and they flow into the unit through the open ditch. The above groups of water are finally collected in wastewater treatment unit as effluent.

2.3 CHARACTERISTICS OF REFINERY EFFLUENT.

The characteristics of refinery effluent can be classified into,

(i). Physical characteristics

(ii). Chemical characteristics.

2.3.1 Physical Characteristics

Total Dissolved Solids

The total solids present in a sample can be divided into dissolved and suspended solid forms. Dissolved solids do not impair with the clarity of effluent although they often change its Colour whereas suspended solids gives the water a turbid or cloudy appearance.

Significance and Use: - solids in water are contaminants. They bring about Colour in wastewater (effluent). Solids in water should not be allowed to exceed the allowable limit in order not to affect the lives of aquatics that are inhabitants of the effluent receiving body.

Turbidity

Presence of colloidal solids, which may be clay or slit particles or microorganisms. Turbidity in water is caused by the presence of suspended and dissolved particles of gas, liquid or solids of organic or inorganic matter.

Significance and Use: A high turbidity obstructs light, thus reducing the growth of marine plants, eggs and larva that are in the lower levels of an aquatic system. This, if not checked affects the lives of aquatic in the receiving body.

Temperature

This is another important property of water and it has influence on the taste of water, in that warm water tastes flat and insipid, partly as a result of the decreased solubility of oxygen and carbon dioxide at elevated temperatures.

Significance and Use: - Temperature is a very important parameter in the lives of living organisms because extremes of temperature could have adverse effects. Also effluent heat loads can cause significant adverse effects on the receiving waters since the increased temperature causes decreased oxygen solubility and greater oxygen utilization both, which reduces the ability of the stream to handle waste loads.

Taste and Odour

These are subjective properties, which are recognized as having a significant effect on its quality. Bad taste and odour in water is due to the presence of some dissolved solids or gases which may be natural in origin e.g. algae or some other micro organisms.

Colour

Due to dissolved matter, usually organic acids similar to those which give its characteristic Colour and which gives upland water a golden yellow Colour.

2.3.2 Chemical Characteristics

The chemical properties of effluent are usually only apparent in the results of analysis but they have a considerable influence on the stability of the water for consumption, to support fish and other aquatics and other industrial purposes. In many ways chemical properties can be more readily measured than some of the physical characteristics like Colour, which are rather subjective in nature.

Important chemical characteristics of effluent are as follows.

a) Alkalinity /Acidity

Mineral acids from industrial water can give much lower PH values. Because of the complex nature of the $C0_2$ /$HL0_3$ system, alkalinity can exist down to PH of 8.2 and acidity can exist up to PH of 4.5

Significance and Use:_alkalinity/acidity measurement is used in establishing levels of chemical treatment to control scale corrosion and other adverse chemical equilibriums. Levels of alkalinity are critical in establishing solubility of some metals, toxicity of some metals and the buffering capacity of wastewater.

b). **pH.**

This is the measure of the intensity of acidity or alkalinity. Water is a weakly ionized substance.

$H_20 \rightleftarrows H^+ + 0H^-$ and the concentration of the ions denoted by H + and $0H^-$ have constant product

$[H +] [0 H^-] = 0.01 \times 10^{-14}$ mole at 25^0 c. If acid is added to water, H^+ increases and OH^- will decrease to maintain the constant product. Conversely if an alkali is added, OH^- increases and H^+ must decrease. The concentration of hydrogen ions is expressed by log $1/H^+$ which results in a range of values from O to 14. Neutral water has PH 7, below 7 is acidic and above 7 is alkaline. Industrial water may have PH values as low as 1 or as high on 13 and often requires neutralization before discharge.

Significance and Use: - PH is a reliable indication of its acidic or alkaline tendency. The PH measurement is an important consideration in determining the corrosive action of water and assessing water treatment particles for industrial proposes.

c). Hardness

This characteristic is due to the presence of metallic ions basically calcium (Ca^{2+}) and magnesium (Mg^{2+}) which posses the properties of preventing lather formation with soap and forming scale in hot water system. Calcium and magnesium ions in water are indicated by the addition of disodium ethylene diamine tetra acetate.

Hardness in water are the primary cause of tube pipe scaling which frequently causes failures due to clogging and loss of heat transfer or both.

Significance and Use: - Hardness in water notably calcium and magnesium are the primary cause of tube and pipe scaling which frequently cause failures and loss of process efficiency due to clogging or loss of heat transfer. It also causes wastage of soap when washing because hard water has soap wasting properties. Measurement of this property in water is essential for cost effectiveness and profit maximization.

d). Dissolved Oxygen (Biochemical Oxygen Demand): -

Oxygen is a vital element in water since without it; only the lowest forms of life can survive. Pollution of water by organic matter rapidly utilizes the dissolved oxygen by biological oxidization with consequent death or destruction of the aquatics.

Significance and Use: dissolved oxygen is required for the survival and growth of many aquatic organisms including fish. The concentration of dissolved oxygen may also be associated with corrosive and photosynthetic activity. The absence of oxygen may permit anaerobic decay of organic matter and the production of toxic and undesirable esthetic materials in water and wastewaters.

e). Oxygen Demand (Chemical Oxygen Demand)

The importance of oxygen in water makes it essential to be able to measure the amount of oxygen required to oxidize impurities in water. Most of the oxygen demand is due to the oxidization of organic matter by microorganism but inorganic reducing agents for example H_2S also consumes oxygen.

Significance and Use: -

The measurement of chemical oxygen demand of an effluent sample is used to monitor and control oxygen consuming pollutants both organic and inorganic in the effluent (waste water).

f). **Nutrients**

Materials such as nitrogen and phosphorus compounds that play an important part in biological growth and are thus necessary for efficient biological treatment of wastes. The presence of nutrients in their oxidized states as nitrates and phosphates is responsible for accelerating alteration in the quality of lake waters, so that the existence of nutrients in effluent discharged to such water sometimes give cause for concern.

Significance and Use: - Nutrient (phosphate) is widely distributed in the environment as both inorganic and organic bound phosphates, because phosphate is a nutrient for photosynthetic organisms. It may be important to monitor and control discharge of treated effluent into various receiving bodies.

When industrial wastes are present, many other chemical characteristics may be of interest. Examples include grease, heavy metals, cyanide, anions, and so on to mention a few.

2.4 EFFLUENT TREATMENT.

The refinery effluent is treated in the wastewater treatment unit. After treatment the treated effluent is been sent for quality evaluation before discharge to the receiving bodies.

The wastewater treatment is designed to treat the effluent water and the sludge discharged from the process areas and facilities in other to meet the standards for trade effluents. For the purpose of this project, the former is being considered i.e. treatment of effluent water.

The main wastewaters normally treated are:

a). Process oily wastewater and sanitary wastewater. This wastewater comes from the process units and sanitary departments respectively. It contains a lots of impurities and organic matter e.g. phenol, MEA solution e.t.c.

b). Oily wastewater.

This wastewater mainly consists of water from oil tankers contaminated with oil.

c). Clean wastewater.

The clean wastewater streams do not require further extensive treatment like the others and will be fed directly to the observation pond.

Clean wastewaters are as follows

- Cooling tower blow down
- Boiler blow down condensate
- Clean rainwater.

Physical, chemical and biological processes in various combinations are commonly used in order to achieve the required degree of treatment.

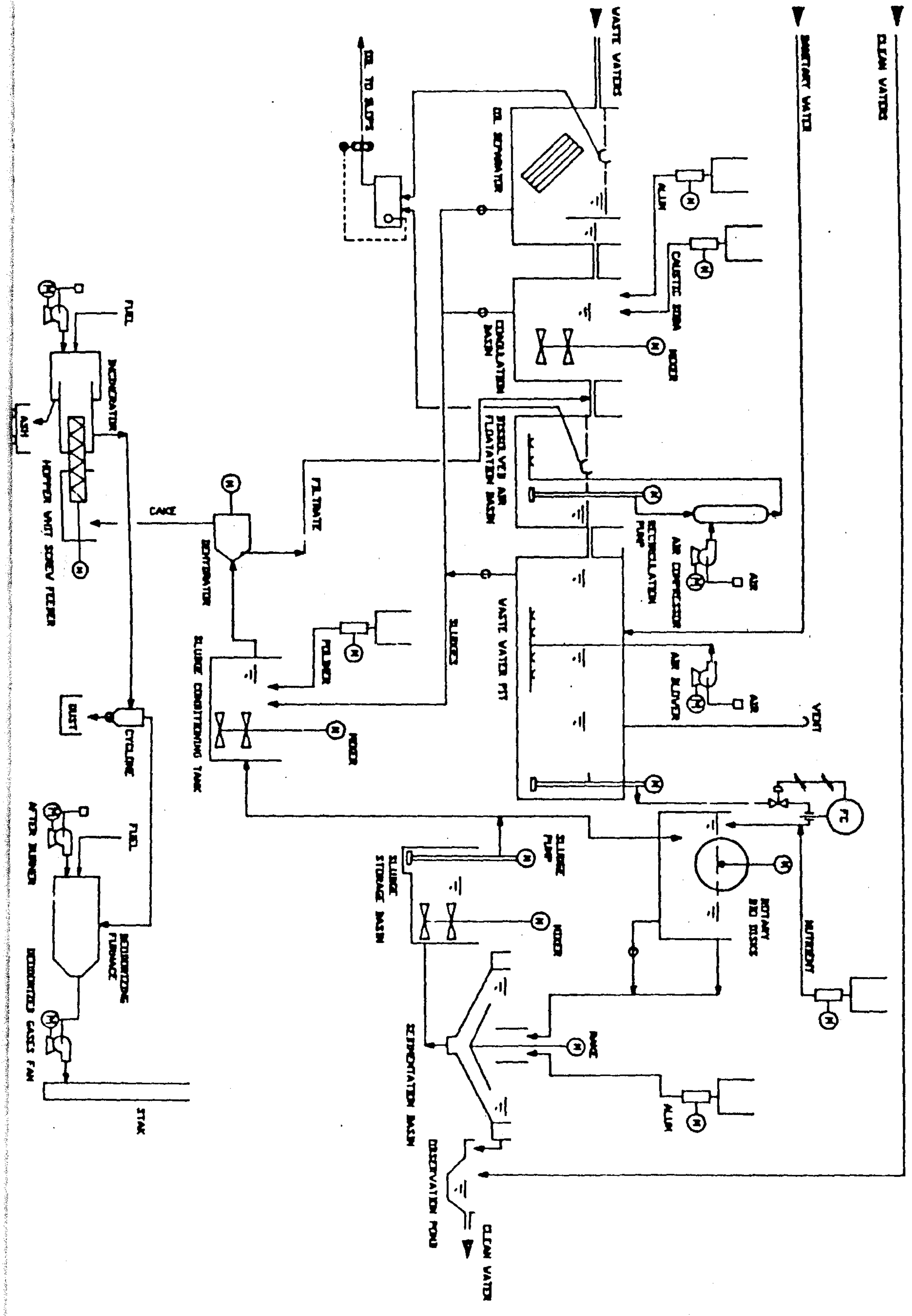

Fig 2.1 Showing a simplified flow diagram of a typical wastewater treatment unit.

2.4.1 Physical – Chemical Processes

- Sedimentation

Settleable solids are removed by simple sedimentation according to the acceptable retention time.

Colloidal solids and the solids that are not settleable or settleable in very long time depending on floc size are removed by coagulation followed by sedimentation or by flotation.

-Coagulation

Coagulation is promoted by the ion of charge opposite to the surface charge that normally colloidal particle in water solution presents. In reducing the particle surface charge by means of counter ions, coagulation occurs because the ions become attached to the surface, increasing particle size and promoting particle aggregation. Depending on the effective electrical surface charge, polymers (polyelectrolytes) anionic or cationic are normally used as coagulants.

Solids having specific gravity only slightly greater than 1.0, which are not removed by coagulation due to an abnormally long sedimentation time. They are removed more effectively by dissolved air floatation in proper basins or tanks.

- Floatation:

Floatation consists of the mixing of wastewater to be treated with air-saturated water recirculated through a pressure drum.

The drum works at about a pressure of 5bar so that when the air dissolved in the water reaches the atmosphere pressure, flotation tank expands to about double it's initial size producing very fine bubbles, which lift to the surface. The bubbles moving up are entrapped inside the coagulated low specific gravity suspended solids decreasing their specific gravity and taking them to the surface. Skimming pipes removes the surface layer of the coagulated suspended solids that are conveyed to the relevant sludge pit.

Chemical additives such as alum facilitate floatation. Their function is to create through very fine suspended solids or bigger surface or structure that can easily absorb or entrap air bubbles.

Dissolved solids are removed from the wastewater by addition of chemicals e.g. caustic soda, alum. Normally chemical addition occurs in coagulation tanks or basins.

- **Dehydration**

Dewatering or dehydration is used to reduce the moisture content of sludge so that it can be handled and processed as a semi solid rather than as a liquid.

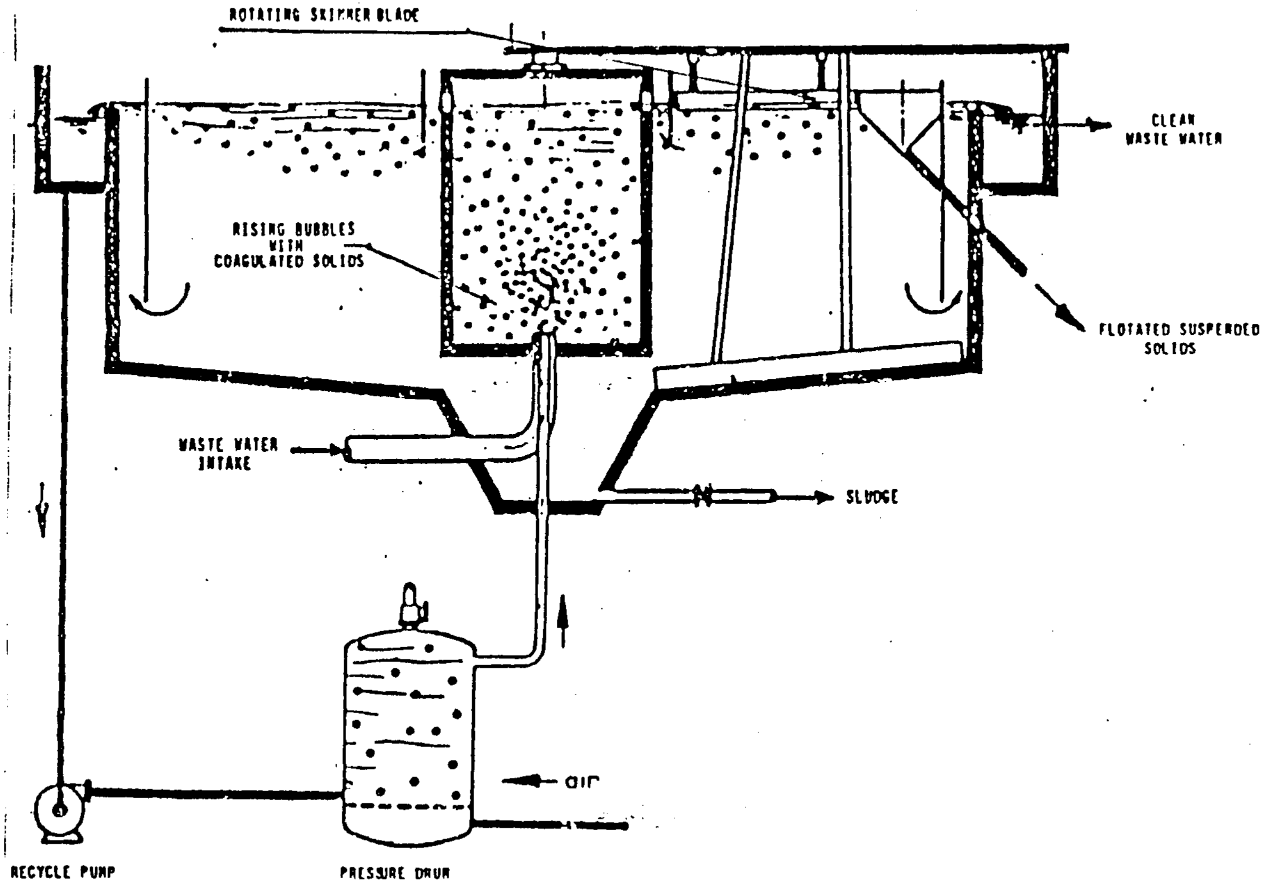

Fig 2.2 Showing the schematic process of floatation

2.4.2 Biological Process

In biological treatment of wastewater the objectives are to coagulate and remove the non-settleable colloidal solids and to remove or reduce the concentration of organic and inorganic components. Many types of microorganisms are active in the breakdown of organic matter and the resulting stabilization of organic wastes. These microorganisms may be broadly classified as aerobic, facultative, anaerobic.

Aerobic organisms require molecular oxygen for their metabolic processes. Anaerobic organisms function in the absence of oxygen and obtain their energy from organic compounds.

Facultative organisms can function aerobically in the presence of oxygen or anaerobically in the absence of oxygen. A majority of the organisms found in biological wastewater treatment processes are of the facultative type.

Most biological systems treating organic waste depend upon heterotopy organisms that utilize organic carbon as an energy source and as a carbon source for cell synthesis. Autotrophy organisms on the other hand do not require an organic carbon source, but rather use an inorganic carbon source such as Co_2 or bicarbonate. Chemosynthetic autotrophs obtain energy from the oxidation of inorganic compounds such as nitrogen or sulphur.

Photosynthetic autotrophs utilize solar energy for the synthesis of Carbon dioxide to cellular protoplasm and produce molecular oxygen as a by-product.

To increase the organic matter, stabilization is necessary mainly to maintain alive the bacteria population, ensuring the proper quantity of nutrient matter and oxygen and the proper value of the PH and temperature.

To ensure the proper quantity of oxygen, Rotary bio disks (RBD) reactor is used. The bacteria population adheres to the surface of the disks that are immersed for about half height into the water to be treated and rotating slowly; about 1.6 Rpm continuously renewing both the surfaces contacting the wastewater and the one contacting the air oxygen.

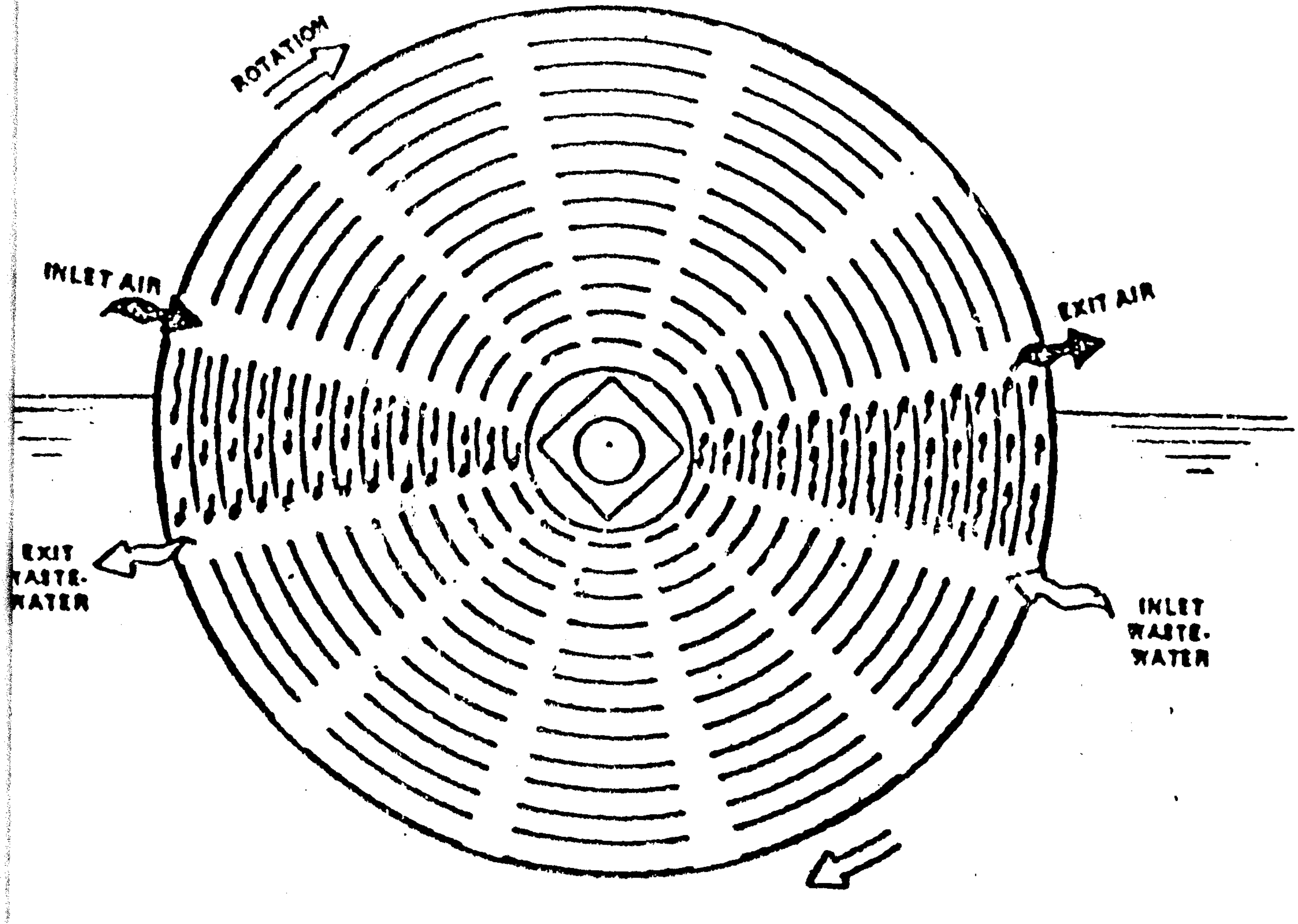

FIG 2.3 Showing the schematic process of a rotary bio disk

2.4.3 Incineration

The bio-sludge from RBD, after the dewatering process is fed to the incineration section. Incineration is used to reduce the organic content and the volume of bio-cake and to produce an odorless and inert residue for final disposal.

It is possible to calculate the oxygen required for a complete combustion assuming that carbon and hydrogen are oxidized to the end products CO_2 and H_20.

2.4.4 Typical Process Flow And Equipment Description

The wastewater, contaminated by oil and organics generally continuously discharged from process areas is fed info the corrugate plate interceptor also called the oil separator. The CPI oil separator is plunged into a pit. The interceptor consists of a pack of several corrugate plates provided with oil and sludge gutters. The gross wastewater flow is splitted into the plates pack increasing the oil separation also because the angle of 45 degrees under which the pack is submerged facilitates the lifting of oily particles and the sludge lowering.

The flow through the bay is assumed from different elevations of inlet channel and outlet compartment. The continuous flow increases the thickness of the surface oil layer until it reaches the slot of skim pipe and to be removed automatically by the same skim pipe.

The settled solids are removed by a vacuum system and fed into a sludge treatment plant. The skimmed oil is collected into the oil sump pit and from there it is pumped to heavy slop oil tanks.

From the oil separator outlet channel, the process wastewater is fed into the coagulation basin on where also same chemicals are used; caustic soda is normally used to adjust the PH value around the neutral point. Alum and anion polymer B polyelectrolyte are added as coagulants, increasing the suspended solids particle size and improving the settling capability. The solids are removed and fed to the dehydration system.

The wastewater and coagulated products are fed to the bio dissolved floatation basin. Recycled wastewater and air are fed into the lower part of DAF basin. The fine air bubbles moving upward are entrapped inside the coagulated suspended products, thus decreasing their specific gravity so lifting them to the surface. Once it reaches the surface, a skimmer removes the oil; the water is fed into the wastewater pit.

The wastewater pit is practically the starting point of the biological treatment. The wastewater and the sanitary water are continuously mixed in the equalization tank and it is also oxygen enriched by air.

From the wastewater pit the sludge is removed and fed to the dehydration system and the water is fed to the rotary bio disk by pumps. The rotary bio disk is a biological reactor that consists of rotary units. During the slow rotation of the partially plunged disk the bacteria that adhere to the RBD (rotary bio disk) surface take the opportunity to produce biomass, oxidizing organic matter and to bind the oxygen necessary for the organic reaction.

To maintain alive the bacteria population, nutrient matter basically nitrogen and phosphorous are fed. The continuously produced biomass is separated by gravity from the treated wastewater. In order not to stop the biological reaction in case of energy failure, one bio disk of each train will be automatically operated for about 5 minutes in turn by emergency power.

The treated wastewater overflows into the sedimentation basin where the slow rotation of the cake and the aid of alum as coagulants reduce the settling time and in crease the bio- sludge separation from the treated water.

The sedimentation basin overflow (treated clear effluent water) reaches the observation pond while the bio-sludge from the bottom is fed to the sludge treatment plant.

CHAPTER THREE.

3.0 EXPERIMENTAL.

A good analytical procedure is of utmost importance in the evaluation of effluent quality. It determines the concentration of contaminants in the effluent water.

The parameters investigated includes the following

(i) Temperature (ii) pH (iii) Turbidity (iv) Conductivity (v) Alkalinity (vi) Chemical oxygen demand (COD) (vii) Biochemical oxygen demand (BOD) (viii) Phosphate content (ix) Phenol content (x) Hardness (total, calcium, and magnesium hardness) (xi) Solids.

3.1 EXPERIMENT I: Determination Of Temperature And pH.

Scope

This test method covers the determination of temperature and pH of effluent water sample.

Apparatus	Reagents
(i) PH meter	(i) Buffer solution.
(ii) Magnetic stirrer (paddle)	
(ii) Magnetic bar	
(iii) Beaker	

Procedure

(a) Distilled water was used to rinse the pH cell.

(b) The effluent water was collected into a beaker and stirred using a magnetic stirrer.

(c) After stirring the effluent sample, and pH electrode was put into the sample and the pH machine was switched on

(d) The measurement button was put on and pH value was indicated on the measurement screen.

(e) The corresponding temperature of the effluent sample was also indicated on the screen.

(f) The electrode was rinsed again with distilled water, in order to stop any interference in subsequent temperature and pH test.

3.2 EXPERIMENT II: Determination Of Turbidity Of Effluent Sample

Scope

This test method covers the determination of turbidity in wastewater.

Apparatus

(i) Photoelectric Nephelometer (ii) Beaker

Reagents

(i) Turbidity standards (ii) Distilled water

Procedure

a) The photoelectric nephelometer was standardized with one value (NTU) of turbidity standard in the measurement range of interest. This is dependent on the closeness in colour between the effluent sample and any of the turbidity standards.
b) The nephelometer was warmed up according to the manufacturers instructions.
c) A clean, dry, scratch free index marked cell was rinsed with an effluent sample.
d) The cell filled with effluent sample was put in an index manner in the instrument and the value was read or recorded. The value of turbidity was recorded in NTU i.e. neplelometric turbidity units.

3.3 EXPERIMENT III: Determination Of The Electrical Conductivity Of Effluent Sample

Scope

This test method covers the measurement of electrical conductivity of effluent (wastewater). It is also used for purposes as in the (i) detection of ionized impurities dissolved in condensed steam (ii) the approximate determination of dissolved electrolytes in natural and treated waters.

Apparatus

(i) Conductivity meter (ii) Conductivity cell (iii) Beaker

Reagents

(i) Distilled water

Procedure

a) The conductivity meter was switched on.
b) The conductivity cell was inserted into the sample in a beaker.
c) The temperature reading on the conductivity meter was adjusted to the temperature of the sample i.e. temperature gotten from pH and temperature determination.
d) The conductivity meter scale was regulated below 20ms/cm and the conductivity reading button was activated.
e) The value of the measured conductivity of the effluent sample was recorded.

3.4 EXPERIMENT IV: Alkalinity Test (Methyl Orange And Phenolphthalein) Of Effluent Sample

Scope

This test method covers the determination of the total concentration of alkaline substance in effluent sample and as such has a direct effect on the pH value.

Apparatus

(i) Electronic titration stand (ii) Magnetic stirrer (iii) Burette and pipette (iv) Beaker

Reagents

(i) Methyl orange indicator (ii) Phenolphthalein indicator (iii) 0.02N HCl (iv) Distilled water

Procedure

For Phenolphthalein

(a) Distilled water was used in rinsing all the beakers, containers and other materials to be used.
(b) 50mls of effluent sample was taken into a beaker
(c) Two drops of Phenolphthalein indicator was added to the sample and upon the addition of this indicator, it was expected that the colour would change to pink. This would mean that alkalinity using phenolphthalein is present. But in this case the sample did not change in colour so alkalinity-using phenolphthalein was not present.

For Methyl Orange

(a) Distilled water was used in rinsing all the beakers, containers and all the materials to be used.

(b) To the sample (effluent sample) used for phenolphthalein above, two drops of methyl orange indicator was added. The colour changed to yellow, which expectedly means that alkalinity using methyl orange is present.

(c) The sample was titrated to a golden yellow end point using 0.02N HCl.

(d) The titre value was recorded and used in the calculation of the alkalinity with methyl orange.

3.5 EXPERIMENT V: Determination Of The Chemical Oxygen Demand (COD) Of Effluent Sample.

Scope

This test method covers the determination of the quantity of oxygen that certain impurities in water will consume based on the reduction of a dichromate solution under specified conditions.

Apparatus

(i) Reflux flasks (ii) Ice-bath (iii) Electronic titration stand (iv) Magnetic stirrer

(v) Reflux digestion equipment (reflux condensers)

Reagents

(i) Distilled water (ii) powdered mercuric sulphate (iii) Concentrated sulphuric acid (iv) 0.25N standard potassium dichromate (v) Sulphuric acid-silver solution (vi) Ferrous ammonium solution (viii) Phenanthroline ferrous sulphate solution.

Procedure

(a) 50ml of distilled water was measured into a reflux flask as the blank sample.

(b) 10ml of effluent water sample was also measured in a reflux flask and it was made up to 50ml by adding 40mls of distilled water.

(c) The reflux flasks were placed in an ice-bath filled up with ice-cubes. 1g of powdered mercuric sulphate were added to each sample i.e. blank and effluent samples. 5mls of concentrated sulphuric acid was also added to the two samples. The sample were properly mixed for complete dissolution.

(d) With the flasks still in the ice-bath 0.25N standard potassium dichromate was added with continuous stirring.

(e) 70mls of sulphuric acid-silver solution was slowly added such that the solution temperature is maintained as low as possible, preferably below 40°C.

(f) The flasks were attached to the condensers and the flow of cold distilled water was allowed through the hoses.

(g) Heat was applied to the flasks and allowed to reflux for 2 hours. A cover was placed over the open end of each condenser to prevent intrusion of foreign materials.

(h) The flasks were allowed to cool and the condensers washed down with 25mls of water before removing the reflux flasks. The acid solution was diluted to about 300mls with distilled water and the solution was allowed to cool to about room temperature.

(i) 8-10 drops of phenanthroline ferrous sulphate solution was added to the two samples and the excess dichromate were titrated with 0.25N ferrous ammonium sulphate solution. The colour change at the end point was sharp changing from blue-green to a reddish hue.

The chemical oxygen demand (COD) was calculated using the titre values of the blank sample and the effluent water sample respectively, normality of the famous ammonium sulphate and the volume of effluent sample used.

3.6 EXPERIMENT VI: Determination Of The Biochemical Oxygen Demand (BOD) Of Effluent Sample

Scope

This test method covers the determination of the biochemical oxygen demand of effluent waters. This test constitutes empirical tests in which standardized laboratory proceedings are used to determine the relative oxygen requirement of the effluent sample.

It is divided into two parts: (i) Dissolved oxygen before incubation and (ii) Dissolved oxygen after incubation.

Apparatus

(i) Electronic titration stand (ii) burette and pipette (iii) Beakers (iv) BOD bottles.

Reagents

(i) Phosphate buffer solution (ii) Magnesium sulphate solution (iii) Calcium chloride solution (iv) Ferrous Chloride solution (v) 0.025N Sodium thriosulphate (vi) Starch indicator (vii) Alkaline iodide-sodium azide solution

Procedure

Dissolved oxygen before incubation

(a) The BOD bottle was filled half way with aerated water and 2mls of effluent sample was added into the bottle. The BOD bottle was later made up with aerated water.

(b) 2mls of manganous sulphate solution was added well below the surface of the liquid.

(c) 2mls of alkaline iodide-sodium azide solution was also added below the surface of the liquid.

(d) The stopper was replaced carefully to exclude air bubbles and inverting the bottle several times also mixed it.

(e) The mixing was repeated the second time after the floc had settled leaving a clear supernatant solution.

(f) When the floc had settled leaving at least 10mls of clear supernatant solution, the stopper was removed and 2ml of conc. Sulphuric acid was added allowing' the acid to run down the neck of the bottle.

(g) It was mixed by inversion until the iodine was uniformly distributed throughout the bottle.

(h) The sample was poured into a 250ml beaker and rapidly titrated with 0.025N sodium thriosulphate to a faint (pale) yellow colour.

(i) 2mls of starch indicator was added and titration was continued to the disappearance of a bare colour to a colorless end point.

The final value was recorded. The dissolved oxygen before incubation was calculated using the amount of 0.025N sodium thriosulphate ($Na_2S_2O_3$) solution required for titration of the effluent sample.

Dissolved oxygen after incubation

(a) Aerated water was used to fill the BOD incubation bottle half way and 2mls of effluent sample was added.

(b) The bottle was made up with aerated water.

(c) The cap of the incubation bottle was closed without leaving air bubbles.

(d) The incubation bottle was stored in the thermostatic chamber (incubator), which was controlled at $20 \pm 1^{0}C$ for 5 days.

(e) After 5 days the same procedure as in the dissolved oxygen before incubation was followed and dissolved oxygen after incubation was also calculated.

(f) After calculating the dissolved oxygen after incubation the biochemical oxygen demand of the effluent sample was calculated using the values of the dissolved before and after incubation, volume of incubation bottle and volume of effluent water sample in the incubation bottle.

Note: - The value of dissolved oxygen before incubation was higher than that of after incubation.

3.7 EXPERIMENT VII: Determination Of Phosphate Content In Effluent Sample

Scope

This method covers the determination of phosphate content in effluent water.

Apparatus

(i) Beakers (ii) Spectrophotometer

Reagents

(i) Ammonium molybdate ramadate

(ii) Distilled water

Procedure

(a) 50mls of distilled water was measured as blank.

(b) 50mls of effluent sample was also measured into a beaker.

(c) 25mls of phosphate reagent (ammonium molybdate ramadate) was added to the effluent sample and the blank.

(d) The blank sample was used to standardize the spectrophotometer.

(e) The absorbance of the effluent sample was determined at a wavelength of 400nm using the spectrophotometer.

The phosphate content was finally calculated using the value of the absorbance, the phosphate constant and dilution factor.

3.8 EXPERIMENT VIII: Determination Of Phenol Content In Effluent Sample

Scope

This test method covers the determination of phenolic compounds in effluent water. The concentration of phenol measured represents the maximum concentration of phenolic compounds present in the sample. This test method is usually used for wastewater treatment.

Apparatus

(i) Beakers (ii) pH meter (iii) Spectrometer (iv) Distillation apparatus
(v) Graduated cylinder

Reagents

(i) Sodium hydroxide (64g/L) (ii) Copper sulphate solution (100g/L) (iii) Distilled water
(iv) Ammonium Chloride solution (v) ammonium hydroxide (vi) Amino antipyrine solution (20g/L) (vii) Potassium Teri cyanide solution (80g/L)

Procedure

The procedure was divided into two parts

(i) Distillation procedure (ii) Colour development

Distillation Procedure

(a) 100mls of effluent sample was measured into a beaker.

(b) The pH of the sample was adjusted to approximately 4.0 with sodium hydroxide solution (64g/L) using the pH meter.

(c) 1mL of Copper sulphate (CuSO4) solution (100g/L) was added.

(d) The mixture (sample mixture) was transferred to the dilution apparatus. A 100ml graduated cylinder was used as a receiver and the mixture was distilled at a temperature of 200°C.

(e) 90mls of distillate was collected and after then distillation was stopped. 100mls of distilled water was added to the distillation flask when boiling ceased.

(f) The distillation was continued until 90-100mls of distillate was collected in the receiver.

Colour development

(a) 50ml of effluent sample was taken from the distillate and the sample was diluted up to 100ml with distilled water.

Note: - the dilution factor used in the calculation was gotten from here: for example if vol. of sample taken was 50ml then dilution factor = 100/50 = 2

(b) 100mls of distilled water was measured as blank.

(c) 5mls of ammonium chloride solution (20g/L) was added to the sample and the blank.

(d) The pH was adjusted between 9.8 – 10.2 using ammonium hydroxide.

(e) 2mls of 4 amino antipyrine solution (20g/L) was added into the sample and blank and they were properly mixed immediately.

(f) The blank was used to standardize the spectrophotometer and then absorbance of the effluent sample was taken at a wavelength of 510nm.

The phenol content was calculated using the absorbance, phenol factor and the dilution factor.

3.9 EXPERIMENT IX: Test For Hardness In Effluent Sample

Scope

This test method covers the determination of the hardness of wastewater (effluent) by titration. This test is divided into two namely: (i) Total hardness (ii) Calcium harness.

Apparatus

(i) Electronic titration stand (ii) Beakers (iii) Burettes and pipettes (iv0 Magnetic stirrer

Reagents

(i) Buffer solution (ii) Hardness indicator (iii) Calcium indicator
(iv) EDTA solution

Procedure

Total hardness

(a) 50mls of sample was measured into the beaker
(b) 0.5ml of buffer solution was added and stirred
(c) 2 to 3 drops of hardness indicator was added and stirred.
(d) The sample was titrated slowly with standard EDTA solution with continuous stirring until the colour changed from red to blue.

The titration was completed within 5 minutes of buffer addition.

The titre value was recorded and used n calculating the total hardness value.

Calcium hardness

(a) 50mls of sample was measured into the beaker
(b) 2mls NaOH solution (50g/L) was added and stirred.
(c) Approximately 0.2g of calcium indicator was added and stirred.
(d) The sample was titrated slowly with standard EDTA solution with continuous stirring until the colour changed from salmon pink to orchid purple.

The titre value was recorded and used in calculating calcium hardness value.

The value of total and calcium hardness was láter used to calculate the value of magnesium harness.

3.10 EXPERIMEN X: Test For Solids In Effluent Water Sample

Scope

This test method describes the procedure for determination of solids in wastewater.

Apparatus

(i) Beakers (ii) Hot plate (evaporating dish) (iii) Desiccators

Procedure

(a) The weight of an empty beaker was taken.

(b) The weighed empty beaker was filled with filtered effluent sample.

(c) Another weighed beaker was filled with unfiltered effluent sample.

(d) The weights of the filtered sample and the unfiltered sample were determined by subtracting weight of empty beaker from beaker + samples (filtered and unfiltered).

(e) The beakers with samples was taken to a hot plate and heated in such a way that it evaporated without boiling.

(f) The samples were allowed to evaporate leaving no trace of liquid on the walls of the beaker.

(g) The beaker with residue was transferred into a Desiccator for about 20 minutes so as to cool.

(h) The weights of the beaker and residue were taken so as to determine the weight of the residue.

The dissolved solids and suspended solids were then calculated.

CHAPTER FOUR

4.0 EXPERIMENTAL RESULTS.

Results were obtained from the experiments carried out. These experiments were repeated for four consecutive weeks thereby giving rise to different results for each parameter for different weeks. An average results was calculated in order to know whether the effluent meet all the requirements before discharge or not.

Below are the results obtained from the experiments carried out.

Table 4.1

The table below shows results obtained for four weeks for temperature, pH, turbidity, conductivity, chemical oxygen demand (COD), Biochemical oxygen demand (BOD), phenol, phosphate.

	Result Obtained For Four Weeks					
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Average Result**	**FEPA Standards**
Temperature (^oC)	29.1	28.6	24.9	25.9	27.13	36 MAX
PH	7.5	7.14	7.25	7.05	7.24	6-9
Turbidity (NTU)	48	39	74	16	44.3	25 MAX
Conductivity (μs/cm)	580	420	300	310	402	500MAX
Chemical Oxygen Demand (mg/L)	40	50	57	62	52.25	60 MAX
Biochemical Oxygen Demand (mg/L)	20.43	24.9	25.4	24.7	23.9	50 MAX
Phosphate Content (mg / L)	5.98	6.64	7.66	9.44	7.43	10 MAX
Phenol Content (mg / L)	0.075	0.098	0.12	0.05	0.086	0.2 MAX

TABLE 4.2

The table below shows the results obtained for four weeks on hardness.

	Results Obtained For Four Weeks On Hardness					FEPA Standards mg/L
Hardness	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Average Result**	
Calcium Hardness mg/L	24	24	22	18	22	
Magnesium Hardness mg/L	6	8	4	10	7	
Total Hardness mg/L	30	32	26	28	29	500 MAX

TABLE 4.3

The table below shows the results obtained for four weeks on solids.

	Results Obtained For Four Weeks On Solids					FEPA Standards (mg/L)
Solids	Week **1**	Week **2**	Week **3**	Week **4**	**Average Result**	
Dissolved Solids mg/L	193.31	179.99	398	494.12	316.36	
Suspended solids mg/L	32.2	40.2	9.01	13.2	23.6	30 MAX
Total solids mg/L	225.30	220.19	407.01	507.32	339.96	2000 MAX

TABLE 4.4

The table below shows the results obtained for four weeks on Alkalinity test (methyl orange and phenolphthalein).

	Results Obtained For Four Weeks On Alkalinity Test					FEPA Standards mg/L
Alkalinity	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Average result**	
Phenolphthalein mg/L	Nil	Nil	Nil	Nil	Nil	
Methyl Orange mg/L	32	28	16	20	24	28MAX

TABLE 4.5

The table below shows the FEPA Standards for all parameters investigated.

Parameter	FEPA **Standard**	Unit
Temperature	36 MAX	°C
PH	6 – 9	
Turbidity	25 MAX	NTU
Conductivity	500 MAX	µs/cm
Biochemical Oxygen Demand	50 MAX	mg/L
Chemical Oxygen Demand	60 MAX	mg/L
Phosphate Content	10MAX	mg/L
Phenol Content	0 –2 MAX	mg/L
Alkalinity Phenolphthalein Methyl orange	Nil 28 MAX	mg/L
Solids (Total Dissolved) Suspended	2000 MAX 30 MAX	mg/L
Hardness	500 MAX	mg/L

CHAPTER FIVE

5.0 DISCUSSION OF RESULT

Results were obtained for each of the parameters investigated. The results were compared with the FEPA standards on effluent limitations and conclusion was drawn. Below is a summary of the discussion of the results obtained from the experiments.

5.1 Temperature And pH

For temperature, the FEPA Standard is 36°C maximum and results from investigation gave 27.13°C, which falls within the standard for effluent limitations as far as temperature is concerned.

pH which is also an important parameter during effluent treatment has the range 6-9 in FEPA Standard for effluent limitation. The result of the investigation gave 7.2, which falls within the allowable limit.

5.2 Conductivity, Turbidity and Alkalinity

For conductivity, the FEPA Standard is 500μs/cm maximum and results from investigation gave 402μs/cm, which obviously falls within specifications. This is evident in table 4.1, which shows results for conductivity and some other parameters.

Turbidity of the effluent sample after investigation gave 44.3NTU and the FEPA designated Standard for this parameter is 25NTU maximum. This reflects the fact that turbidity did not meet the FEPA Standard for effluent limitation.

Alkalinity test gave an average result of 28mg/L for methyl orange and Nil for phenolphthalein, which indicates that Alkalinity with phenolphthalein indicator was not present as required by the FEPA Standards. Alkalinity by methyl orange has 28mg/L as FEPA Standard and results of investigation on Alkalinity with methyl orange gave 24mg/L, which falls within the FEPA allowable limits.

5.3 Biochemical Oxygen Demand and Chemical Oxygen Demand

Results of investigation on biochemical oxygen demand gave 23.9mg/L as against the FEPA Standard for this parameter, which is 50mg/L maximum. This shows that this parameter falls within the allowable limits of the Federal Environmental Protection Agency (FEPA).

Chemical oxygen demand test gave 52.25mg/L as the results of the investigation. The FEPA allowable limit for this parameter is 60mg/L maximum and this result shows that chemical oxygen demand of the effluent falls with the FEPA allowable limit. This is evident on table 4.1 in chapter 4.

5.4 Phosphate Content, Phenol Content and Solids

Phosphate content in the effluent investigated was found to be 7.43mg/L, it was compared with the FEPA Standard of 10mg/L maximum. This shows that the phosphate content in the effluent sample is of FEPA allowable limit.

Phenol content after investigation gave an average result of 0.086mg/L. the FEPA Standard for this parameter is 0.2mg/L maximum. This shows that phenol content in the effluent sample falls within FEPA allowable limit.

Test for solids in effluent, which is in two parts, namely total solids and suspended solids gave average results of 339.96mg/L and 23.6mg/L respe3ctively. The FEPA Standards for these parameters are 2000mg/L maximum and 30mg/L maximum. The results of investigation when compared with the FEPA Standard show that solids in the effluent sample fall within the FEPA allowable limit.

5.5 Total hardness

Investigation on total hardness of the effluent sample gave an average result of 29mg/L, which when compared with the FEPA Standard Of 500mg/L maximum shows that total hardness falls with FEPA specifications.

From the above discussion, it can be deduced that all the parameters met the FEPA Standards for effluent limitations except Turbidity, which gave an average result of 44.3NTU, which is much higher than the FEPA Standard of 25NTU maximum. Turbidity alone did not meet the FEPA allowable limits.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Comparing the results obtained from investigation with the FEPA standards on effluent limitations. It is quite obvious that almost all the parameters investigated fell within the FEPA allowable limits except for turbidity, which is one of the physical properties of effluent. This is not to say that turbidity as a physical property is not an important factor worthy of critical consideration, but it will only require some little more efforts in the clarifier during wastewater treatment.

In conclusion, the effluent discharged by the Kaduna refinery and petrochemical company is virtually a pollution free one as far as the parameters investigated are concerned.

6.2 Recommendations

For effective production of effluent with FEPA standard quality the following are recommended.

6.2.1 Maintenance: The most important point/target in the operation of wastewater treatment units is to produce clarified water of good quality within FEPA limitations constantly.

This unit handles wastewater automatically and mechanically. Therefore mechanical and electrical equipment, devices, instruments should be well maintained on a constant basis. All the equipments should have appreciable maintainability level which in turn give these various equipments the ability to be in a state to perform a required function under given conditions at a given instant of time. This also increases the dependability, reliability and availability of these equipments.

6.2.2 Effective Communication: Effective communication is of great importance in the smooth running of any plant. In the oil refinery, the quality of effluent from a wastewater treatment plant will definitely be disturbed by sudden changes in influent quantity, pressure, flow rate, temperature to mention a few. Proper communication is vital between the various staff in the different sections of the refinery in order to produce products of standard quantity.

6.2.3 Operation Records: The operating condition in the wastewater treatment plant should be inspected continually and recorded in details as much as possible. This is also significant in the production of high quality and pollution free effluent in the sense that different chemical and reagent used in water treatment unit are added at particular pressure, temperature, and flow rate etc.

6.2.4 Skillful Operators: The operators of wastewater treatment unit should be operators with immense knowledge, dedication and should put the right attitude towards their various jobs. Manuals should be made available for reference purposes if need be. Skillful operators will keep the unit in an excellent operating condition and produce effluent that satisfies the laid down standards.

6.2.5 Good Training Programmes: The man power development department should put together some good training programmes such as utilities basic course, laboratory technicians basic course etc. These training programmes are of immense significance because it impacts new skills and knowledge in the various staff of the refinery.

6.2.6 Quality Control: Quality control is virtually the most important stage of effluent treatment. It certifies the effluent treated fit for discharge. Because of this reason, this department should be given proper attention. Equipments, instruments, re-agents etc should be in good shape for effective judgment of the treated effluent. The surroundings of this department should be kept clean at all times.

APPENDIX

SAMPLE CALCULATIONS

1 Temperature

First week = 29. 1°c, second week = 28.6°C

Third week =24.9°c, Fourth week = 25. 9°C

Average value for temperature

$$= \frac{(29.1 + 28.6 + 24.9 + 25.9)}{4}\ ^{\circ}C$$

$= 27.13^{\circ}C$

2 pH

First week = 7.5, second week, 7.14, third week = 7.25, fourth week = 7.05

$$\text{Average value for pH} = \frac{7.5+ 7.14 + 7.25 + 7.05}{4}$$

$= 7.24$

3 Turbidity

First week = 48 NTU, Second week = 39 NTU

Third week = 74 NTU, Fourth week = 16 NTU

Average value for Turbidity

$$= \frac{(48 + 39 + 74 + 16)}{4}\ \text{NTU}$$

= 44.3 NTU

4 Conductivity

First week = 580 μs/cm. Second week = 420 μs/cm

Third week = 300 μs/cm, Fourth week = 310 μs/cm

Average value for conductivity

$$= \frac{(580 + 420 + 300 + 310)}{4}\ \mu s/cm$$

= 402μs/cm

5 Chemical Oxygen Demand

$$\text{COD mg/L} = \frac{(A-B) \times N \times 8000}{S}$$

Where A = Ferrous ammonium Solution required for titration of blank sample, ml

= 24.2 ml

B = Ferrous ammonium sulphate solution used for the titration of effluent sample, ml.

= 24 ml

N = Normality of the ferrous ammonium sulphate solution = 0.25 N.

S = Sample used for experiment, ml

= 10 ml

$$\therefore \text{COD mg / L} = \frac{(24.2 - 24) \times 0.25 \times 8000}{10}$$

= 40 mg / L

∴ COD mg / L for first week = 40mg / L.

The same calculation was done for the remaining three weeks using different samples and the following result were obtained.

Second week, COD mg / L = 50 mg /L

Third week, COD mg / L = 57 mg / L

Fourth week, COD mg / L = 62 mg/ L

∴ Average value for COD mg /L

$$= \frac{(40 + 50 + 57 + 62) \text{ mg / L}}{4}$$

= 52. 25 mg /L

6 Biochemical Oxygen Demand

$$BOD = \frac{(D1-D2)\ X\ T}{V}$$

Where D1 = Dissolved oxygen of diluted water sample before incubation, mg / L

Where D2=Dissolved oxygen of diluted water sample after incubation, mg/L

T = Total volume of incubation bottle, ml after 5 days.

V = Volume of sample water in incubation bottle, ml

DOB = Dissolved oxygen before incubation

$$= \frac{T\ X\ 0.2\ X\ 1000}{\text{Capacity of bottle (vol)}}$$

Where T = milliliters of 0.25N $Na_2S_2O_3$ solution used for the titration of the sample from the burette. =11.4

Dissolved oxygen before incubation (D1)

$$= \frac{T\ X\ 0.2\ X\ 1000}{\text{Capacity of bottle} = 294\text{ml}} \qquad = \frac{11.4 \times 0.2 \times 1000}{294}$$

$$=7.755\text{mg/L}$$

Dissolved oxygen after incubation (D2) $= \frac{T\ X\ 0.2\ X\ 1000}{294}$

$$= \frac{11.196X0.2X1000}{294} = 7.616\text{mg/L}$$

$$\therefore BOD = \frac{(D1 - D2)\ X\ T}{V}$$

Where V = 2

$$= \frac{7.755 - 7.616x\ 294}{2} \qquad = 20.43$$

BOD = 20.43 mg /L.

Same thing was done for the remaining three weeks and the following results were obtained.

Second week, BOD = 24.9mg/L.

Third week, BOD = 25.4 mg /L

Fourth week, BOD = 24.7 mg /L

$$\text{Average BOD} = \frac{(20.43 + 24.9 + 25.4 + 24.7)}{4} \text{ mg /L}$$

$$= 23.9 \text{ mg/L}$$

7 Phosphate Content

$$\text{Phosphate} = \text{Absorbance at 400nm} \times 16.65134 \times 3.066 \times \frac{50}{V}$$

$$\text{Absorbance at 400nm} \times 16.65134 \times 3.066 \times \frac{50}{V}$$

Where V = dilution factor = 50 ml

16.65134, 3.066, 50 are all phosphate constants.

Phosphate absorbance at 400nm=0.117

∴ Phosphate content for first week

$= 0.117 \times 16.65134 \times 3.066 \times 50/50$

$= 5.98$ mg /L

Absorbance was taken for the other sample on the second, third and fourth week and the same calculation was done.

Second week, phosphate content = 6.64

Third week, phosphate content = 7.66

Fourth week, phosphate content = 9.44

Average value for phosphate content

$$\frac{5.98+6.64+7.66+9.44}{4} = 7.43\text{mg/L}$$

8 Phenol Content

Phenol content = Absorbance at 510nm x 9.862 x $\frac{100}{V}$

Phenol absorbance at 510nm = 0.0038

V = dilution factor = 50ml

= 0.0038 x 9. 862 x $\frac{100}{50}$ = 0.075mg/L

Same calculation was done for the other remaining weeks.

Second week = 0.098. Third week = 0.12

Fourth week = 0.05

:. Average value for phenol content

= $\frac{(0.075 + 0.098 + 0.12 + 0.05)}{4}$ mg /L

= 0.086 mg /L

9 Hardness

Total hardness for the fist week

= Titre value x $\frac{1000}{50}$

Titre value = point (on the burette) at which Colour change is noticed

∴ Total hardness = Titre value (1.5 ml) x $\frac{1000}{50}$ = 30 mg /L

Total hardness for first week = 30 mg /L

Calcium hardness

= Titre value x $\frac{1000}{50}$

Titre value for calcium hardness = 1.2

∴ Calcium hardness = 1.2 x $\frac{1000}{50}$ = 24 mg /L

Magnesium hardness = total hardness – calcium hardness

= (30 – 24) mg /L

= 6 mg /L

Same calculation was done for the remaining three weeks and results obtained are

Second week, Total hardness = 32 mg /L

Calcium hardness = 24 mg /L

∴ Magnesium hardness = (32 – 24) mg/L

= 8mg/L

Third week, Total hardness = 26 mg/L

Calcium hardness = 4 mg/L

∴ Magnesium hardness =(26 – 4) mg/L

=22mg/L

Fourth week, Total hardness =28mg/L

Calcium hardness = 18mg/L

∴ Magnesium hardness =(28 – 18) mg/L

=10mg/L

Average result for total hardness, calcium hardness and magnesium hardness are

$$\text{Total hardness} = \frac{(30 + 32 + 26 + 28)}{4} \text{ mg /L} = 29\text{mg/L}$$

$$\text{Calcium hardness} = \frac{(24 + 24 + 22 + 18)}{4} \text{ mg /L} == 22 \text{ mg /L}$$

$$\text{Magnesium hardness} = \frac{(6 + 8 + 4 + 10)}{4} \text{ mg /L}$$

= 7mg /L

10 Solids

For first week, total solids (using unfiltered samples) =

Weight of empty beaker = 28. 2983

Weight of empty beaker + sample = 47.3840

Weight of sample = 19. 0857

After boiling

Weight of beaker + residue = 28.3026

$\therefore$ Weight of residue = (Beaker + Residue) – Beaker

= 28.3026 – 28. 2983

= 0.0043

$\therefore$ To calculate total solids in sample

$$= \frac{\text{Residue}}{\text{Sample}} \times 10^6 \text{ mg/L}$$

$$= \frac{0.0043}{19.0857} \times 10^6 \text{ mg/L} = 225.3 \text{ mg/L}$$

For Dissolved solids (using filtered sample)

Weight of beaker = 26. 9416

Weight of beaker + sample = 46.6224

Weight of sample = 19.6808

Weight of beaker + residue (after boiling)

= 26.9454

Weight of residue = 26.9454 – 26.9416

= 0.0038

$\therefore$ Dissolved solids in sample

$$= \frac{\text{Residue}}{\text{Sample}} \times 10^6 \text{mg/L}$$

$$= \frac{0.0038}{19.6808} \times 10^6 \text{mg/L}$$

= 193.1 mg /L

Suspended solids = total solids - dissolved solids

= (225.3 – 193.1) mg /L = 32.2 mg /L

Same calculation was done for the remaining three weeks.

Second week

Total solids = 220.19 mg /l

Dissolved solids = 179.99 mg/L

Suspended solids = 40.2 mg /L

Third week

Total solids = 407.1 mg /L

Dissolved solids =398mg /L

Suspended solids = 9.01 mg/L

Fourth week

Total solids = 507.32 mg /L

Dissolved solids = 494 .12 mg

Suspended solids = 13.2 mg

Average results for total solids, dissolved, and suspended solids are.

Total solids : $\frac{(225.30 + 220.19 + 407.01 + 507.32)}{4}$ mg /L

= 339.96mg /L

Dissolved solids

= $\frac{(193.1 + 179.99 + 398 + 494.12)}{4}$ mg /L

= 316.36 MG/L

Suspended solids

= $\frac{(32.2 + 40.2 + 9.01 + 13.2)}{4}$ mg /L

= 23.6mg /L

11 Alkalinity

Phenolphthalein for all the four weeks was nil

For methyl orange

First week

= Titre value x $\frac{1000}{50}$

Titre value for methyl orange = 1.6

$= 1.6 \times \frac{1000}{50} = 32$ mg /L

Second week

Titre value $\times \frac{1000}{50} = 1.4 \times \frac{1000}{50} = 28$ mg /L

Same was done for third and fourth week

Third week = 16 mg /L

Fourth week = 20 mg /L

∴ Average value for Alkalinity (Methyl orange)

$= \frac{(32 + 28 + 16 + 20)}{4}$ mg /L = 24 mg /L

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