CHARACTERIZATION OF SEWAGE AND DESIGN OF A UASB REACTOR FOR ITS TREATMENT

A Thesis submitted in partial fulfillment
For the requirement of the degree of

Bachelor of Technology in Civil Engineering

By
ANUPAM KUMAR VERMA
SIDDHANT KUMAR

Department of Civil Engineering
National Institute of Technology Rourkela
2013

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Anupam Kumar verma (109CE0066)
Siddhant Kumar (109CE0546)

Under the guidance of
Prof. Kakoli K. Paul

Department of Civil Engineering
National Institute of Technology Rourkela
2013

CERTIFICATE

National Institute of Technology
Rourkela

This is to certify that the thesis entitled “Characterization of sewage properties and design of a UASB reactor for its treatment” submitted by Anupam Kumar Verma, Roll No. 109CE0066 and Siddhant Kumar, Roll No. 109CE0546 in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Civil Engineering at National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date: (Prof. KAKOLI K. PAUL)

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Anupam Kumar Verma (109CE0066)

Siddhant Kumar (109CE0546)

Department of Civil Engineering
National Institute of Technology
Rourkela – 769008

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ABSTRACT

Wastewater treatment is becoming ever more critical due to fading water resources, increasing wastewater disposal expenses and firmer discharge regulations that have lowered permissible contaminant levels in waste streams. The ultimate goal of wastewater management is the protection of the environment in a manner commensurate with public health and socio-economic concerns. Understanding the nature of wastewater is fundamental to design appropriate wastewater treatment plant and technologies.

This project is devoted for the characterization of general parameters of domestic waste water collected from the campus of NIT Rourkela, and study and design of an anaerobic treatment plant, the Upflow Anaerobic Sludge Blanket reactor (UASB). The UASB model showed promising results in removal of BOD, heavy metals, pH, turbidity and decrease in microbe content.

A laboratory scale Upflow Anaerobic Sludge Blanket reactor study was done with waste water generated from hostels in NIT Rourkela as substrate. The reactor was fed with waste water in the presence of sludge generated from the same waste water. The substrate was recirculated within the reactor to ensure a continuous steady upflow. Samples were collected from the reactor every week and were analyzed for concentration of various parameters and were plotted against time. Treated waste water found from UASB model reduces turbidity of water decreases from 57.1 to 37.6 NTU, pH of treated water increases s from 7.9 to 8.9,BOD of treated sample decreases with time from 6.6 to 1.5 mg/L, concentration of metals decreases with time as Potassium concentration decreases from 2.066 to 1.351 mg/L, Calcium concentration decreases from 2.391 to 1.075 mg/L, Zinc concentration decreases from 0.251 to 0.162 mg/L, Iron concentration decreases from 0.517 to 0.239 mg/L, Copper concentration decreases from 0.107 to 0.056 mg/L, Lead concentration decreases from 0.033 to 0.202 mg/L, Arsenic concentration decreases from 0.09 to 0.048 mg/L, magnesium concentration decreases from 6.439 to 6.145 mg/L.

And after characterization of these properties proper treatment was designed and dimension of treatment plant was calculated. Diameter of collection pit was calculated to be 6m and depth to be 5m. Coarse screen of 5-6mm spacing is provided and fine screen of 1-3mm spacing is provided after coarse screen. Rectangular sedimentation tank of 25m length, 3m wide and 3m height is provided. A UASB treatment plant of 15m length, 9m wide and 3m height is provided. Sludge drying bed has length 6m, width 3m and height 1m. Secondary sedimentation tank of 20 m dia is provided.

Keywords:-UASB, sludge, anaerobic, discharge, effluent, sedimentation

CHAPTER 1
INTRODUCTION

General

Wastewater is a combination of water and water-carried wastes originating from households, commercial and industrial amenities and institutions. Untreated wastewater generally contains high levels of organic material, numerous pathogenic microorganisms, nutrients and toxic compounds leading to environmental pollution and health hazards. So, the waste water must be treated appropriately before final disposal, which leads to protection of the environment with public health and socioeconomic concerns.

It is a mixture of sewage water, manufacturing waste effluents, agricultural drainage and hospitals facilities; it is well known that the wastewater from domestic origin contains pathogens, suspended solids, and other organic and inorganic pollutants. In order to diminish the environmental and health hazards, these contaminants and impurities need to be brought down to permissible limits for safe disposal of wastewater. Therefore, removal of the organic contaminants and pathogens from wastewater is of paramount important for its reuse in different activities (pollutants in waste water: European committee). The waste water that flows after being used for domestic, industrial, manufacturing and other purposes is known as sewage. Sewage comprises water as the main constituent, while other constituent, and include organic waste and chemical. Sewage discharge is one of the problems presently facing Rourkela and several efforts are being vigorously pursued to control it (Rakshit and Sudeep, 2010). Assessment of water and wastewater is very crucial to safeguard public health and the environment. Sewage discharges are a major source of water pollution, contributing to demand of oxygen and nutrient loading of the water bodies; promoting toxic; algal blooms and leading to a destabilized aquatic ecosystem. (Kushwah and Vajpayee, 2011) The problem is compounded in areas where wastewater treatment systems are simple and not efficient. The conventional wastewater treatment technologies as adopted in industrialized nations are expensive to build, operate and maintain especially for de-centralized communities. Research efforts are underway for the development of treatment technologies suited to these decentralized communities. (OECD, 2009)

The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without causing any danger to human health or damage to the natural environment which may be unacceptable. Irrigation with wastewater is both disposal and utilization and indeed is an effective form of wastewater disposal (as in slow-rate land treatment) (N. R.M; 2010). However, some degree of treatment must normally be provided to raw municipal wastewater before it can be used for any agricultural or aquaculture purposes. The effluent quality used in agriculture has a great outcome on the operation as well as performance of the wastewater-soil-plant and also of aquaculture system. The required quality of effluent in the case of irrigation depends on the crop or crops which are to be irrigated, the soil conditions and properties and also on the system of effluent distribution adopted. (N. R.M 2010). By means of crop restriction and by selecting irrigation systems which could minimize health risk, the grade of pre-application treatment of waste water can be reduced. A analogous approach is not possible in aquaculture systems and more trust will have to be placed on controller through treatment of waste water.

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UASB technology

For developing countries, the anaerobic treatment offers an attractive prospect. With many options available for treatment of municipal and industrial effluents, the anaerobic treatment process stands ahead because of minimum sludge formation and production of energy in the form of methane. For the past several decades the research on fundamentals of anaerobic digestion was going on and the total duration of digestion process has come down with the advancement of high rate anaerobic processes. (FAO, CHAPTER SIX, 2009)The relative size of these high rate digesters is quite small and the space occupied is also less. Instead of flat and short reactors as used earlier, tall reactors are being applied. The loading rates for high rate anaerobic digesters are comparatively high, because of the retention of active granular settle able sludge in the reactor. The basic studies of the microbiological and biochemical aspects of anaerobic digestion have revealed many of the characteristics and nutritional requirements of individual and groups of anaerobic bacteria, while pilot and full scale engineering studies have demonstrated the operational requirements and instabilities often encountered in the process. (NATO/CCMS; 1998)

Among the high rate anaerobic digestion processes, the UASB process stands ahead for its wide ranging applications for all types of wastes (BREF : UASB). The only drawback of the process is slow start-up in the absence of granular seed sludge (Bowen, 1979).

The present work is done on a laboratory scale UASB reactor treating domestic waste water in the presence of digested sludge, and experiments of the treated sludge taken every week from the pilot model were conducted to study the effects of recirculation of the same waste water.

Advantages of using UASB technique:

1) Less energy requirement

2) Less biological sludge production

3) Fewer nutrients required

4) Methane production

5) Elimination of off shore gas pollution

6) Rapid response to substrate addition

7) Periods without feeding

8) Methane from sludge dewatering plants can be converted into biogas, but it can also be converted into hydrogen, which can be used in direct fuel cells. Thus another option for the powering of wastewater plants is also possible.(SWP-VOL 21)

Disadvantages of UASB technique:

1) Sensitive to adverse effects of low temperature

2) More susceptible to upsets due to toxic substances

3) May require alkalinity addition

4) Biological N and P removal is not possible.

CHAPTER 2

LITERATURE REVIEW

Various techniques adopted other than conventional treatment plant

1) Study of Waste Water Quality Management in IIlawarra Coal Mines

R. N. Singh; University *of Wollongong (1998)*

The waste auditing technique provides a powerful tool to assess periodically the efficacy of the mine wastewater treatment system. This will provide an opportunity to the mine operators to change the mining and processing conditions so that the environmental and economic goals can be achieved. This technique has been successfully applied to a mine site in the mawarra region where wastewater of dissimilar chemical characteristics could be segregated into separate streams for further treatment. Improved process of water managements systems is also proposed. Relatively simple alterations to the operation of the coal wash filtration drains are expected to reduce the periods of inefficient operation of these drains by 95%. As highlighted I this paper, often there is significant economic benefit resulting from the application of waste minimization. In addition, there is always a major benefit to the environment

2) Study of COD removal efficiency of AH reactor and UASB reactor

Tarek A. Elmitwali, et al (1999) investigated the treatment of sewage at a temperature of 13°C in three reactors (each 3.84 liters) a UASB and two anaerobic hybrid (AH) reactors with small sludge granules with an average diameter of 0.73 mm. The use of small sludge granules and operating the reactors at low up flow velocity (1.8 m/d) improved suspended COD removal efficiencies for the UASB reactor. Moreover, the use of sheets in the AH reactors significantly increased suspended COD removal efficiencies as compared to the UASB and reached to 87% for pre-settled sewage treatment

3) Innovative Biological treatment processes for wastewater in Canada

Catherine N. Mulligani and Bernard F. Gibbs (2004)

Biological treatment of wastewater has been engaged successfully for numerous types of industries. Aerobic processes have been used expansively. Large production of sludge is the main problem and methods such as bio filters and membrane bioreactors are being developed to combat this occurrence. Anaerobic waste treatment has experienced noteworthy developments and is now consistent with low retention times. The UASB though a high rate anaerobic reactor is now becoming less prevalent than the EGSB reactor. New developments such as the Annam ox process are highly promising for nitrogen removal. For metal removal, processes such as bio sorption and bio surfactants combined with ultrafiltration membranes are under development. Bio surfactants have also shown promise as dispersing agents for oil spills. Wetlands can be used to reduce biological oxygen demand (BOD), total suspended solids (TSS), nutrients and heavy metals if sufficient space is available.

4)High strength sewage treatment in a UASB reactor

Nidal Mahmoud (2007): The upflow anaerobic sludge blanket (UASB) reactor is extensively used in tropical nations for sewage treatment, such as India and Brazil. The ambient temperature in these countries, ranges between 20 and 30 degree Celsius throughout the year (Aiyuk et al, 2006; Von Sperling and Chernicharo, 2005) and sewage is of low to medium strength. The present challenge in development of anaerobic technology is to alter the system to treat municipal sewage in severe situation. For example, in Jordan and Palestine sewage is has high COD concentrations greater than 1000 mg/L.

5) A framework for efficient waste water treatment and recycling systems

Gayathri Devi, Mekala Brian Davidson, Madar Samad and Anne-Maree (2008)

Wastewater has a number of substitute uses and each substitute is connected with a set a costs from the start of treatment to the start of use. Consequently, wastewater recycling can fulfill more than one objective like: decrease the nutrients discharge to natural water bodies, save or substitute drinkable water, and fetch more land under cultivation and above all saving water for environmental purposes. In Melbourne treatment of waste water was even used for thrusting a rocket. In current experiments, the researchers have demonstrated that nitrous oxide gas could be produced under laboratory conditions from wastewater by means of a low-oxygen technique but there's a drawback in the process. Nitrous oxide is a noteworthy greenhouse gas and is more than 300 times more powerful than carbon dioxide.

6) Domestic waste water treatment using Fixed Bed Biofilm and Membrane Bioreactor.

Ida Medawatyi and R. Pamekas(2011) used membrane bioreactor and fixed film bed biofilm in waste water treatment for water reuse in urban housing area. Their research indicated that water treatment reuse trains have probable application for treating domestic wastewater in urban housing area for non-portable water source. They engaged treatment system using fixed bed biofilm or bio-filter system that could yield water reuse standard quality and also advised substitute technology using MBR system for possible application for treating primary treatment municipal wastewater treatment plant effluent. It was found that the water quality reuse from these operations met the standard for public and urban purposes of use according to USEPA, 2004 [12].

7) Membrane System for cost efficient treatment of waste water

Pawar Avinash Shivajirao (2012) recommended for membrane systems for treatment of waste water with additional technical advancement and equivalent cost reductions, making them capable of purifying waters in single step processes at reasonable costs. Around one-third for wastewater and two-thirds of the market will be for water. His result further supported the Membrane technologies for receiving superior recognition as substitutes to conventional water treatment and also for enhancing treated wastewater effluent for reuse applications that can ominously decrease operation and maintenance costs and energy use.

8) UASB technology for Indian dairy industry

R.Thenmozhi(2007) suggested the UASB technique for paper industry. The Indian dairy industry is said to have a growth of more than 15% and waste water is composed to exceed 150 million tons per annum. Biological wastewater treatment has been accomplished in many different ways .To overcome the drawbacks of attached and suspended growth systems Up flow Anaerobic Sludge Blanket reactors are designed. UASB is a typical hybrid type of reactor, which involves both attached and suspended growth process. This study includes the dairy industry wastewater treatment through UASB reactor by fluctuating the retention times in days for a specific organic loading rate. This has efficiently removed BOD, COD and other parameters due to its combined attached growth and suspended growth processes

9) Combined Application of UV Photolysis and Ozonation with Biological Aerating Filter in Tertiary Wastewater Treatment

Zhaoqian Jing and Shiwei Cao (2012)

The effluent from the secondary clarifiers of the WWTP includes many organic pollutants, most of which are difficult to be decomposed. Direct treatment along with additional biological processes cannot make acceptable performance. AOPs are usually effective in refractory pollutants elimination and can be combined with biological processes in a very low biodegradable wastewater treatment. UV and O3 oxidation was combined with Biological Aerating Filter (BAF) in tertiary treatment. The tests results indicated that though UV photolysis alone was not quite effective for COD elimination, it could improve its performance of ozonation because when UV photolysis was combined along with ozonation, COD in the wastewater secondary effluent was removed by 45%.

CHAPTER 3
STUDY AREA

FOR COMPARISION OF BATHROOM AND KITCHEN WASTE WATER ANALYSIS SAMPLING POINTS ARE:-

1) HBH- Homi Bhabha hall of NIT Rourkela

2) Vikram Sarabhai hall of residence of NIT Rourkela

For designing of treatment plant an anaerobic treatment plant (UASB reactor) was employed. Under anaerobic conditions, organic pollutants in waste water are degraded by microbes producing methane and carbon dioxide. The degradation process is effective compared to more conventional aerobic processes and produces only 5-10% sludge. This saves considerably on cost and associated with sludge disposal. In a UASB reactor, the waste to be treated is introduced in the bottom of the tank and the waste water flows upwards through a blanket of sludge composed of biologically formed granules or particles. Treatment occurs as the water comes in contact with the granules.

BATHROOM WASTE WATER AND KITCHEN WASTE WATER SAMPLING PROCEDURE

The water sample of the kitchen has been collected into a normal air tight bottle of capacity of 2 liters. A mug has been used to take the kitchen waste water into the same type of bottle. Similarly 5 samples of bathroom and kitchen waste water at 5 different times of h 9.00am ,1.00pm,5.00pm,7.00pm and at 9.00pm were collected from various hostels of NIT Rourkela has been collected and experimented. The procedure was adopted to get the average value of the required parameters of duration

CHAPTER 4

METHODOLOGY

Methodology for the project can be divided into two parts:-

1. Characterization of waste water parameters
2. Design of treatment unit

METHODOLOGY FOR DETERMINATION OF PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF WASTE WATER:-(IS 3025)

4.1METHODOLOGY FOR MEASUREMENT OF pH VALUE (IS 3025: Part 11)

The pH of a sample is nothing but the negative logarithm of concentration of hydrogen ion. pH fluctuates from 6-8 in sample of waste water, due to hydrolysis of salts of acids and bases. Hydrogen Sulphide, Carbon dioxide and Ammonia which are dissolved upset pH value of water. pH value may be greater than 9 in alkaline springs and the pH equal or less than 4 for acidic ones. Industrial and manufacturing wastes do upset the pH as it depends on buffer capacity of water. pH value of water sample in lab changes because of loss or, reactions with sediments, absorption of gases, chemical reaction taking place within the sample bottle. Therefore pH value should sooner be evaluated at the time of collection of sample. pH can be determined electrometrically or calorimetrically.

4.1. 1 PRINCIPLE

The pH of the waste water sample is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode.

4.1.2. APPARATUS USED

- pH meter – With glass and reference electrode
- Thermometer

4.1.3. PROCEDURE

The instrument with a buffer solution of pH near that of the sample is standardized and electrode against at least one additional buffer of different pH value is checked. The temperature of the water is measured and if temperature compensation is available in the instruments it is adjusted accordingly. After the standardization place the sample in the beaker and immerse the electrode, then take the reading in the pH meter and the temperature (SW-846).

4.2 METHODOLOGY FOR MEASUREMENT OF TURBIDITY (IS 3025: Part 10)

4.2.1. PRINCIPLE

It is centered on comparison of the intensity of light scattered by the sample under convinced conditions with the intensity of light scattered by a standard reference suspension under the similar conditions.

4.2.2. APPARATUS USED:

- Sample tubes –clear and colorless sample tubes are taken
- Turbidity meter :Systronics digital nephtelo-turbidity meter 132 was taken

4.2.3. PROCEDURE

- Three pin plugs was inserted into appropriate 230V AC mains socket.
- The instrument was switched on and was allowed 10-15 minutes to warm up.
- An appropriate range was selected.
- A CALIB control was set to the maximum in clockwise position.

- The test tube was inserted in distilled water into cell holder and was covered with light shield.
- A SET ZERO control was adjusted to get zero on the display.
- The test tube was adjusted and the test tube containing standard solution was replaced.

  And CALIB control was set up for display the result.
- The instrument now ready for test samples test tube containing unknown sample in cell holder is inserted. The display directly gives the turbidity in NTU (Laboratory manual, NIT Rourkela).

4.3 METHODOLOGY FOR MEASUREMENT OF BIOCHEMICAL OXYGEN DEMAND (IS 3025: Part 44)

4.3.1PRINCIPLE

Bio-chemical Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose organic waste. If there is a bulky quantity of organic waste in the water supply, a lot of bacteria will also be present to decompose this waste. In this case oxygen demand will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or detached through the water, BOD levels will begin to decline (Field book).

4.3.2 APPARATUS USED

- Incubation bottles- 300 ml capacity
- Magnetic stirrer

4.3.3 PROCEDURE

The unknown sample was placed in the incubation bottle where 4 capsules (4 gm.) of NaOH had been kept at the neck of the bottle. A magnetic stirrer was continuously rotated inside the bottle. Then it is kept air tight by means of special caps attached with an electronic meter. The electronic meter directly gives records BOD reading at every 24 hour. Now the bottles are preserved in the Refrigerator for days as per requirement of study. The same procedure can be adopted for BOD 3 days and BOD 5 days (Laboratory manual, NIT Rourkela).

4.4 METHODOLOGY FOR MEASUREMENT OF DISSOLVED OXYGEN (IS 3025 : Part 38)

4.4.1. PRINCIPLE:

The Winkler Method uses titration to determine dissolved oxygen in the water sample. A bottle is filled completely with water such that no air is left to skew the results. The dissolved oxygen in the sample was then "fixed" by adding a series of reagents which forms an acid compound which is then titrated by means of a neutralizing compound that causes the color change. The color change point is called the "endpoint," which coincides with the dissolved oxygen concentration.

4.4.2 REAGENT LIST

- 2ml Manganese sulfate
- 2ml alkali-iodide-azide
- 2ml concentrated sulfuric acid

- 2ml starch solution
- Sodium thiosulfate

4.4.3. PROCEDURE:

- Carefully a 300-mL glass Biological Oxygen Demand (BOD) stoppered bottle was filled brim-full with sample water.
- Immediately 2mL of manganese sulfate was added to the collection bottle by inserting a calibrated pipette just beneath the surface of the liquid. (If the reagent is added above the sample surface, oxygen will be introduced into the sample.) The pipette was slowly squeezed so that so no bubbles are introduced via the pipette.
- 2 mL of alkali-iodide-azide was added reagent in the same manner.
- The bottle was closed with stopper with care to be sure no air is introduced. The sample was mixed by inverting several times. Air bubbles were checked; the sample was discarded and started over if any are seen. If oxygen is present, a brownish-orange cloud of precipitate or floc would appear. When this floc would have settled to the bottom, the sample was mixed by turning it upside down several times and let it settle again.
- 2 mL of concentrated sulfuric acid was added through a pipette. Carefully stopper was placed and was inverted several times to dissolve the floc. At this point, the sample has become "fixed" and can be stored in a cool dark place for up to 8 hours. As an added precaution distilled water was squirted along the stopper as a precaution, and the bottle was capped with aluminum foil and also with a rubber band during the storage period.
- 200 mL of the sample was titrated with sodium thiosulfate to obtain a pale straw color.

- Titration was done by slowly releasing the titrant solution from a standard calibrated pipette into the flask and continuously swirling or stirring the sample water.
- 2 mL of starch solution was added to get a blue color forms.
- Titration was continued until the sample blue color decolorizes. Care has to be taken to ensure that each drop is carefully mixed with sample before the next drop is added. The number of milliliters of the titrant used gives directly the amount of dissolved oxygen in mg/l.

4.5 METHODOLOGY FOR MEASUREMENT OF HARDNESS (IS 3025: Part 21)

4.5.1 PRINCIPLE

Total hardness measures the amount of calcium and magnesium and is expressed in terms of calcium carbonate. As, to remain healthy, our body needs both Calcium and Magnesium. If water would be too hard then it would not only decrease the washing capability of many soaps and detergents but will also affect the taste of the water (SDWF).

4.5.2APPARATUS USED

- A pipette –(Minimum 50 ml capacity)
- Glass bottle (4-8 oz.)

4.5.3PROCEDURE

- 50 ml. of the sample was pippeted into 4 – 8 oz. glass bottle.
- The standard soap solution was added in small portions at first (0.5 ml.), shaking vigorously after each addition.

- As the end point comes closer, the quantity added should be decreased by 0.1 ml. for each addition.
- A perpetual lather is created which is last for 5 minutes with the bottle on its side, and the ml. of soap solution used was recorded.
- The soap solution was added in small quantities. If the lather again vanishes, the first point obtained was incorrect due to the existence of magnesium salts. (The ml. of soap used to obtain this false end point may be used for calculation of the approximate magnesium hardness by substituting in the formula used for calculation.)
- The soap solution was continuously added until the true end point is reached and ml. used was recorded.
- Sample is diluted to 50 ml. with freshly boiled and cooled distilled water (Laboratory manual, NIT Rourkela).

4.6 METHODOLOGY FOR MEASUREMENT OF ALKANITY (IS 3025: Part 23)

4.6.1. APPARATUS USED

1) Pipette – Minimum 100 ml. capacity

2) Erlenmeyer flask

3) A burette

4.6.2 REAGENTS USED

1) Phenolphthalein indicator

2)0.02N sulfuric acid

3) Methyl orange indicator

4.6.3 PROCEDURE

1) 100 ml. of the sample was pipetted into the Erlenmeyer flask and the same quantity of distilled water was taken into another.

2) 3 drops of phenolphthalein indicator was added to each.

3) If the sample shows pinkish color 0.02N sulfuric acid was added from a burette until the pink color just vanishes and no. of ml. of acid used was recorded.

4) 3 drops of methyl orange indicator was added to each flask.

5) If the sample becomes yellow in color, 0.02N sulfuric acid is added until the first difference in color is noted in comparison with the distilled water. If the end point is orange the no. of ml. of acid used is recorded.

4.7 METHODOLOGY FOR MEASUREMENT OF ACIDITY (IS 3025: Part 22)

4.7.1. APPARATUS USED

1) Pipette – Minimum 100 ml. capacity

2) Erlenmeyer flask

3) A burette

4.7.2 REAGENTS USED

1) Phenolphthalein indicator

2) 0.02N sodium hydroxide

4.7.3. PROCEDURE

1) 100 ml. of the sample was pippeted into an Erlenmeyer flask.

2) Then 3 drops of phenolphthalein indicator was added.

3) 0.02N sodium hydroxide from burette was added until the first permanent pink color appears and the no. of ml. of sodium hydroxide used was recorded (Laboratory manual, NIT Rourkela).

4.7.4. CALCULATION

ml.of 0.02N sodium hydroxide × 10 = p.p.m. total acidity expressed in terms of CaCO3

4.8 METHODOLOGY FOR MEASUREMENT OF TOTAL SOLIDS (IS 3025: Part 15)

4.8.1 APPARATUS USED

1) Pit crucible

2) A desiccator

3) Flask or pipette

4.8.2. PROCEDURE

1) The pit crucible was cleaned and was placed in a 103 degree Celsius oven for 1 hr.

2) The crucible was placed in a desiccator until cools, and then it was weighed.

3) The sample thoroughly was mixed and was measured as 100 ml. by volumetric flask or pipette.

4) The sample was transferred to the dish and the flask was rinsed or pipetted several times with small portions of distilled water and the rinsing was added to the dish. It has to be making sure that all suspended matter is completely transferred to the crucible.

5) After the sample is evaporated, the crucible is dried and residue in the 103^0C oven for 1 hr., cool in the desiccator and weigh (Laboratory manual, NIT Rourkela).

4.8.3. CALCULATION

[Increase in weight (cm) × 1000] ÷ Ml. of sample = ppm total solids

4.9 METHODOLOGY FOR MEASUREMENT OF CHLORIDE PRESENT (IS 3025: Part 32)

4.9.1 APPARATUS USED

1) Porcelain evaporating dish

2) A burette

3) A pipette

4.9.2. REAGENTS USED

1) Potassium chromate indicator

2) Standard silver nitrate solution

4.9.3. PROCEDURE

1) 50 ml. of the sample was pippeted in the porcelain evaporating dish.

2) The same quantity of distilled water was placed into second dish for color comparison.

3) 1 ml. of potassium chromate indicator was added to each.

4) Standard silver nitrate solution was added to the sample from a burette, a few drops at a time, with constant alternating until the first permanent reddish coloration appears. This can be determined by comparison with the distilled water. The ml. of the silver nitrate solution used was recorded.

5) If more than 7 or 8 ml. of silver nitrate solution is required, the entire procedure should be repeated using a smaller sample diluted to 50 ml. with distilled water (Laboratory manual, NIT Rourkela).

4.9.4. CALCULATION

[(Ml. of silver nitrate used – 0.2) × 500] ÷ Ml. of sample = p.p.m. chloride

4.10 METHODOLOGY FOR MEASUREMENT OF METALS LIKE Fe, Cu, Ca, Mg etc. BY ATOMIC ABSORPTION SPECTROMETRY (AAS) (IS 3025: Part 45-49)

4.10.1. PRINCIPLE

Atomic absorption spectrometry (AAS) resembles emission flame photometry in that a sample is aspirated into a flame and atomized. The main difference is that in a photometry the amount of light emitted is measured, whereas in AAS a light beam is directed through the flame, into a monochromator , and on to a detector that measures the amount of light absorbed by the atomized element in the flame. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

4.10.2. APPARATUS USED:

1) Burner

2) Recorder

3) Lamps

4) Pressure reducing valves

5) Vent

6) Atomic absorption spectrometer

4.10.3. REAGENTS USED

1) Air

2) Acetylene

3) Metal free water

4) Standard metal solution ¡V a series of standard metal solutions of respective metals in optimum concentration range by appropriate dilution of the stock metal solution

4.10.4. PROCEDURE

1) In general according to the manufacturer’s operating manual the experiment is proceeded.

2) A hollow cathode lamp for desired metal in the instrument was installed and roughly the wavelength was set. The silt width was set according to the manufacturer’s suggested setting for element being measured. The instrument was turned on, and the hollow cathode lamp the current was applied as suggested by the manufacturer, and instrument warmed up until energy source get stabilized, generally about 10 to 20minutes.

3) The wavelength was optimized by adjusting wavelength dial until optimum energy gain is obtained. Align lamp in accordance with manufacturer’s instructions.

4) A suitable burner head was installed and burner head position was adjusted. Turn on air and adjust flow rate to that specific by manufacturer to give maximum sensitivity for the metal being measured.

5) The acetylene was turned on and flow rate to value specified was adjusted, and flame was ignited. Aspirate a standard solution and adjust aspiration rate

of the nebulizer to obtain maximum sensitivity. A standard is atomized and burner was adjusted both up and down and sideways to obtain maximum response. The absorbance of this standard was recorded when freshly prepared with a new hollow cathode lamp.

6) The instrument is now ready to operate. Firstly the standard solutions and stock solutions is placed to obtain a graph of the respective metal concentration and the unknown sample to get the value of the metal present with respect to the respective graph (APHA)

CHAPTER 5

RESULTS AND DISCUSSION

5.1 WASTE WATER CHARACTERIZATION

1)HOMI BHABHA HALL OF RESIDENCE:

PROPERTIES/TIME	7 AM	10 AM	1 PM	6PM	10PM	MAXIMUM VALUE
TURBIDITY (NTU)	143	186	259	241	294	259
ACIDITY (ppm)	5.2	5.7	4.1	4.9	3.8	5.7
ALKANITY (ppm)	6.1	6.4	5.3	7.2	4.1	7.2
PH VALUE	6.4	6.93	5.85	6.55	6.3	6.93
DISSOLVED OXYGEN (mg/L)	8.4	6.9	10.8	6.5	11.8	11.8
BOD (mg/L)	11.3	10.4	16.7	12.3	15.9	16.7
CHLORINE (ppm)	127	157	84	75	116	157
TOTAL SOLIDS (mg/L)	820	465	922	679	1239	1239

(TABLE 1)

2) VIKRAM SARABHAI HALL OF RESIDENCE:

PROPERTIES/TIME	7 AM	10 AM	1 PM	6PM	10PM	MAXIMUM VALUE
TURBIDITY (NTU)	359	175	241	261	285	359
ACIDITY (ppm)	5.1	5.4	4.6	3.2	7.1	7.1
ALKANITY (ppm)	6.9	7.6	3.3	4.8	4.6	7.6
pH VALUE	7.7	5.33	6.1	6.95	6.71	7.7
DISSOLVED OXYGEN (mg/L)	9.1	7.6	11.4	4.4	10.9	11.4
BOD (mg/L)	17.4	11.2	14.9	11.8	12.6	17.4
CHLORINE (ppm)	115	140	105	79	72	140
TOTAL SOLIDS (mg/L)	874	653	750	1164	800	1164

(TABLE 2)

MAXIMUM VALUE OF THE PARAMETERS OF WASTE WATER OBTAINED FROM TWO HALLS:

PROPERTIEES/HOSTELS	HOMI BHABHA	VS HALL	MAXIMUM VALUE
TURBIDITY (NTU)	259	359	359
ACIDITY (ppm)	5.7	7.1	7.1
ALKANITY (ppm)	7.2	7.6	7.6
pH VALUE	6.93	7.7	7.7
DISSOLVED OXYGEN (mg/L)	11.8	11.4	11.8
BOD (mg/L)	16.7	17.4	17.4
CHLORINE (ppm)	157	140	157
TOTAL SOLIDS (mg/L)	1239	1164	1239

(TABLE 3)

DETERMINATION OF METALS BY ATOMIC ABSORBTION SPECTROSCOPY:

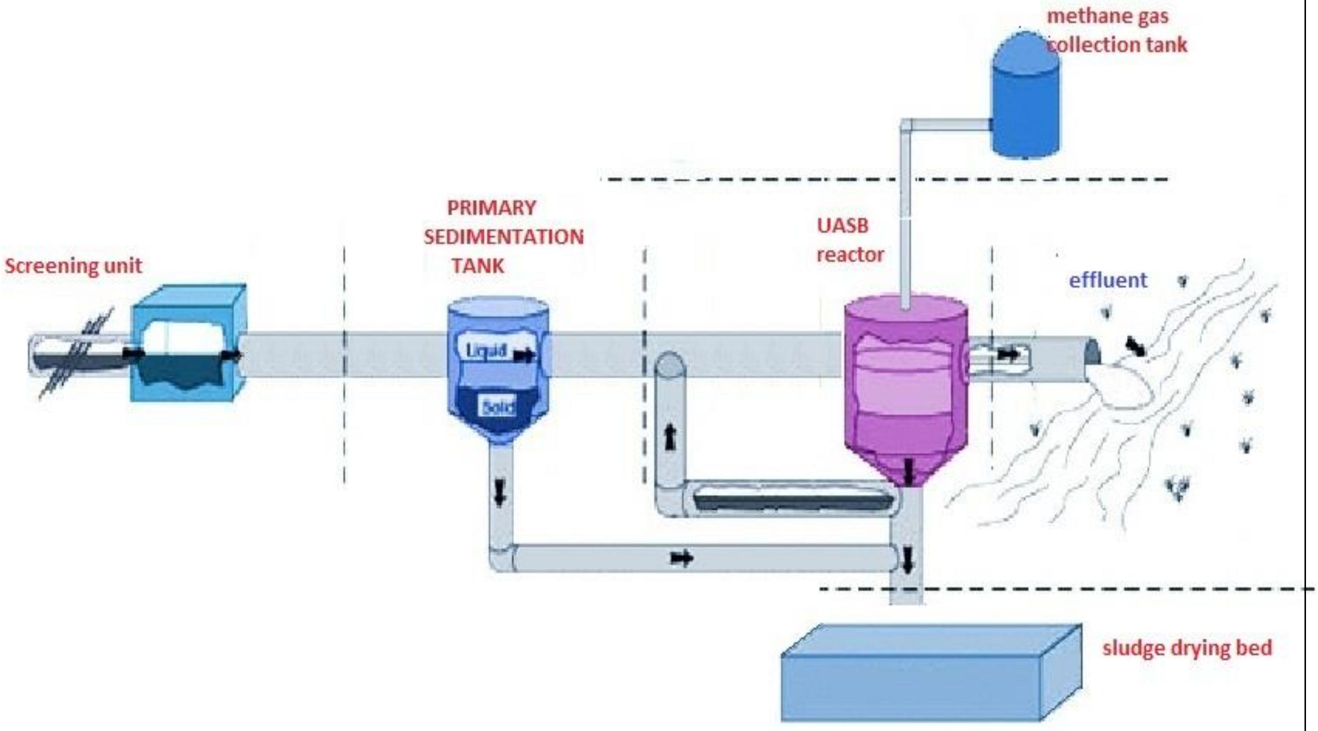
METALS	7 AM	10 AM	1 PM	6PM	10PM	MAXIMUM VALUE)
POTASSIUM	0.197	0.113	0.088	0.110	0.121	0.197
MAGNESIUM	0.611	1.978	1.923	1.632	1.543	1.978
CALCIUM	1.761	1.636	5.41	1.97	0.281	5.41
ZINC	0.216	0.191	0.012	0.129	0.113	0.216
IRON	0.247	0.149	0.611	0.927	0.112	0.927
COPPER	0.213	0.142	0.332	0.161	0.108	0.332
LEAD	0.117	0.128	0.111	0.368	0.172	0.368
ARSENIC	0.062	0.098	0.126	0.084	0.097	0.126

(TABLE 4)

By comparison of the properties, the following properties are exceeding above permissible values as per the IS CODE 3025.

1. Turbidity
2. Biochemical Oxygen Demand (BOD)

5.2 DESIGN OF TREATMENT PLANT



Model of waste water treatment:
(FIG. 5.1)
Source: (NMSU: HYDROLOGY,2001)

DESIGN OF TREATMENT PLANT

Total water supply from CPH = 601500 liters

Total supply from hostels = 764000 liters

Therefore total flow of water = 1365000 liters

Total sewage flow = 0.8 x water supplied

=0.8x1365000

=1092000 liters

Total peak flow = 2.7 x1092000

=2948400 liters /day

=2948400/86400= 34.12 liters/sec

=0.03412 m^3/sec

Assuming that velocity through screens is not allowed to exceed 0.8 m/sec

Net area of screen openings required =

=0.0341/0.8

=0.0426 m^2

DESIGN OF COARSE SCREEN:

Using rectangular screen bars in the screen having 1 cm width and placed at 5cm clear spacing, we have

Gross area of screen required = (0.0426 x6) /5

=0.05112 m^2

Assuming screen bars are 60 degree to the horizontal, we have

Gross area of screen needed = 0.05112 / (0.866)

=0.06m2

FINE SCREENS:

They are to be placed after coarse screen to prevent clogging of particles

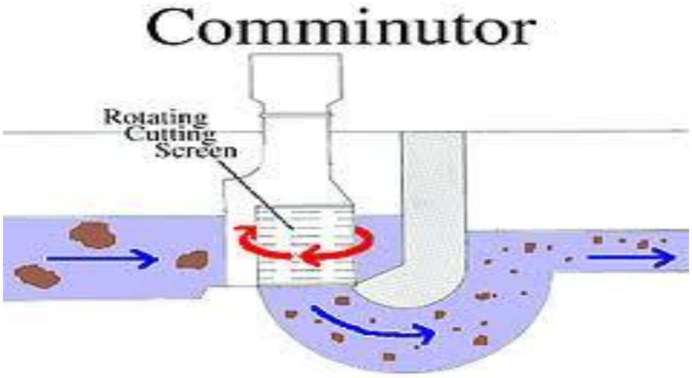
Fine screens spacing is between 1mm-3mm in size

Taking area of screen same as coarse screen, we adopt a fine screen of 0.06 m2 and spacing 1.2 mm in size.

DESIGN OF COMMINUTOR:

We need to provide comminutor to break larger sewage solids to about 6mm in size

(FIG 5.2)
Communitor



(VCCS: LESSON 13)

RECTANGULAR SEDIMENTATION TANK :

Sewage flow (peak) = 2.94 million liters per day

Now for plain sedimentation tank:

Taking detention period as 2 hours

Quantity of sewage to be treated in 2 hours

i.e. Capacity of tank required Q= 2.94 /24 x 2= 0.245 million liters

$=245m^3$

Now assuming flow velocity through the tank is maintained at 0.3 m/min, we have

Length of tank required = velocity of flow x detention period

=0.3 x (2 x60)

=36m

Cross –sectional area of tank required = capacity of the tank /length of the tank

$= 245 /36\ m^2$

$=6.80\ m^2$

Assuming the water depth in the tank 2.5 m

Width of the tank required = 6.80 /2.5 =2.72 m

Taking breadth of tank 5m other than 2.72 m

Now assuming free board of 0.5 m

Overall depth =3+0.5 =3.5m

Hence providing rectangular sedimentation tank with overall size of 36 m x 5 m x 3.5 m

<u>CHECKING THE OVERFLOW RATE:</u>

Overflow rate should be between 20000-40000 liters /m^2 /day

= Q / (BX L)

= 2.94 x 10^6 /(5 x 36)

= 16333.33 liters /m^2/day

So now modifying the tank to get desired overflow rate =

Area of tank required = 2.94 x10^6 /40000 = 73.5m^2

So providing length =25m

And width =73.5/25 =2.94 m

So we are providing sedimentation tank of dimension =25 m x 3m x 3m

<u>DESIGN OF UPFLOW ANAEROBIC SLUDGE REACTOR:</u>

Total feed suspended solids = 250 ppm

Assuming it has efficiency of 80 % removal

So outlet suspended solids = 250 – 0.8 x 250

= 50 ppm

So load on clarifier =250-50

=200 ppm

Thus, UASB has to be remove 200 ppm of suspended solids

Therefore sludge generated per day = 2.94 x 10^6 x 200 /10^6

= 588 kg

Assuming solid - content in feed = 3%

3 kg of solid is present in 100 kg sludge

So 588 kg of suspended solids will be present in = 588x100 /3

= 21600 kg

Now assuming specific gravity of sludge = 1.25 gm. / liter

= 1.25×10^3 kg /m^3

So volume of sludge generated per day = 21600/ (1.25×10^6)

= 17.28 m^3 /day

SIZE OF REACTOR:

Assuming sludge retention time as 40 days

Assuming hydraulic retention time = 9 hours

Flow rate = 45 m^3 /hour

HRT = reactor volume / flow rate

Therefore reactor volume = 9 x 45

= 405 m^3

Assuming depth = 3 m

Area of bed = 405 / 3 =135 m^2

Up flow velocity = 0.333 m /hour

In order to retain any flocculent sludge in reactor at all-time velocity should not be more than 1.2 m /hour at peak flow

So design is O. K.

DESIGN OF SLUDGE DRYING BED:

Let number of days sludge to be dried = 10 days

Sludge withdrawn /day =21600 gm.

= 21.6 kg

Total volume of sludge = 21600 /(1.25×10^3)

= 17.28 m^3

Taking height of sludge = 1m

Area of bed = 17.28 / 1 =17.28 m^2

Taking sludge drying bed =6m x 3m

So dimension of sludge drying bed = 6m x 3m x 1m

SECONDARY SEDIMENTAION TANK:

Here the detention period is high as =4 to 8 hours

Assuming surface loading rate of 20 m^3 /day / m^2

Surface area required = (2.94 x 10^6)/ (10x 20)

= 147 m^2

Adopting a circular tank = (147 x 4 / 3.142) ^0.5

= 15 m

Weir loading for a circular weir placed along the periphery of the tank

Having length 15 m will be = 2.94 x 10^6 / (10^6 x 15)

= 62.38 <150

So design is O. K.

Hence providing 20m diameter secondary settling tank

5.3 DESIGN OF PILOT LABORATORY SCLAE UASB REACTOR

PRINCIPLE:

In UASB process oxygen is not required as it is anaerobic and thus it is money saving process. Even for low suspension waters this process is suitable .The principle of UASB derives in channeling of water to the top of tank from its bottom. Process forms a blanket of granular sludge and remains suspended in the tank. UASB is very suitable high BOD waste water. Methane, a viable renewable energy, is a byproduct of this anaerobic treatment process.

APPARATUS USED:

1. Cylindrical vessel (15 cm radius, 60 cm height)
2. Water pump
3. Valve
4. Water pipes
5. Gas outlet pipe
6. Gas collecting bottle

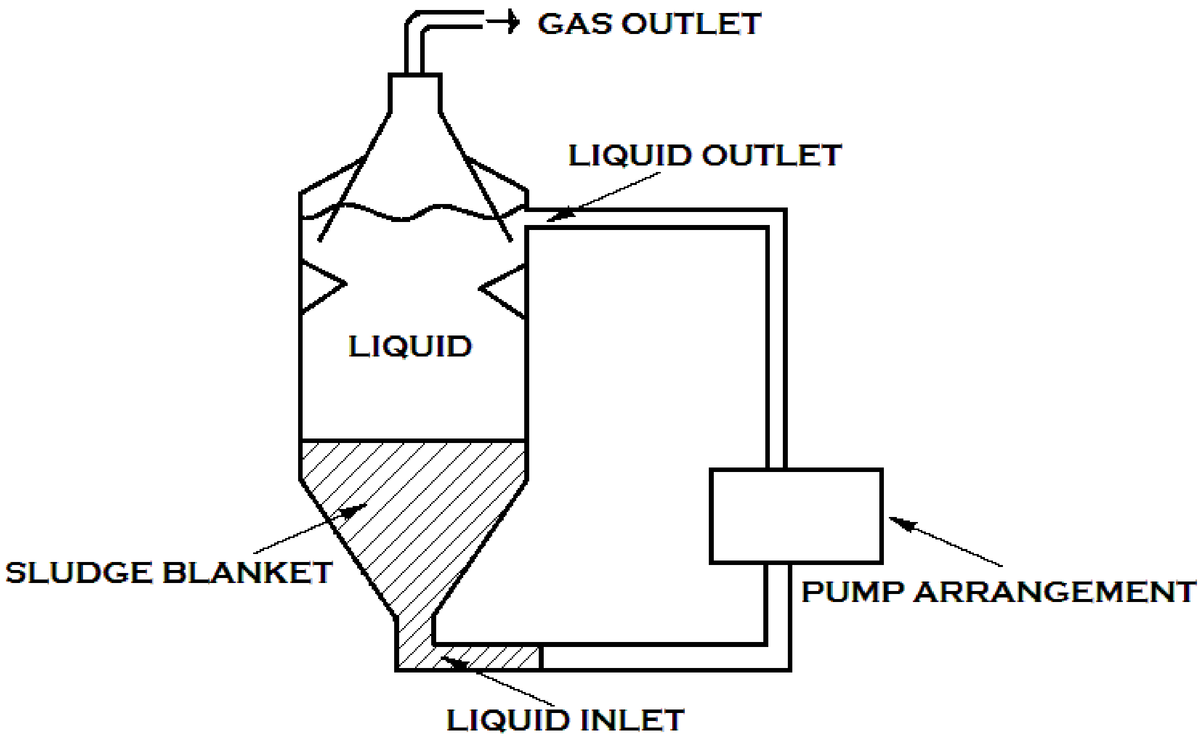
REAGENT USED:

1. Soda lime

PROCEDURE:

1. The container volume was 15 liters, of which one-third was filled with digested sludge and the remaining was filled with waste water.
2. The recirculation pump was connected at the bottom of the tank which pumped the waste water from the top of the tank
3. The recirculation velocity was checked using a valve at the inlet.
4. The gas produced in the process was collected in a bottle via a delivery tube.
5. The gases produced in the process were CO_2 and methane. CO_2 gas was separated from methane by passing the effluent from a solution of soda-lime.

6. At the end of the process the effluent waste water was collected and tested for various physical, chemical and biological properties and was compared with the initial waste water and the standard values. (IS 3025).



Laboratory arrangement for pilot laboratory scale UASB reactor
(fig. 5.3)

5.4 PARAMETERS OF EFFLUENT FROM UASB REACTOR

Samples were taken every week to test for the following four properties of the effluent of the reactor

1) TURBIDITY
2) pH VALUE
3) BOD
4) MICROBE COUNT

PROPERTIES/TIME	WEEK 1	WEEK 2	WEEK 3	WEEK 4
TURBIDITY(NTU)	57.6	56.2	37.3	34.1
pH VALUE	7.9	8.2	8.4	8.9
BOD (mg/L)	6.6	6.4	3	1.5
MICROBE COUNT (ppm)	$21*10^6$	$19*10^6$	$16.5*10^6$	$15*10^6$

(TABLE 5)

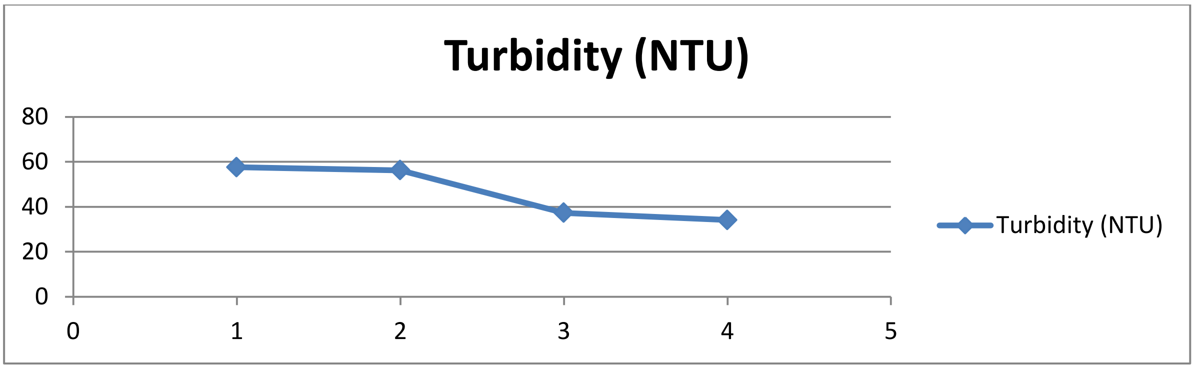
5) METAL CONTENT

METALS	Week 1	Week 2	Week 3	Week 4
Potassium(mg/L)	2.066	1.722	1.523	1.351
Calcium(mg/L)	2.391	1.942	1.892	1.075
Zinc(mg/L)	0.251	0.216	0.192	0.162
Iron(mg/L)	0.517	0.436	0.393	0.239
Copper(mg/L)	0.107	0.091	0.071	0.056
Lead(mg/L)	0.033	0.012	0.192	0.202
Arsenic(mg/L)	0.090	0.092	0.062	0.048
Magnesium(mg/L)	6.439	6.349	6.221	6.145

(TABLE 6)

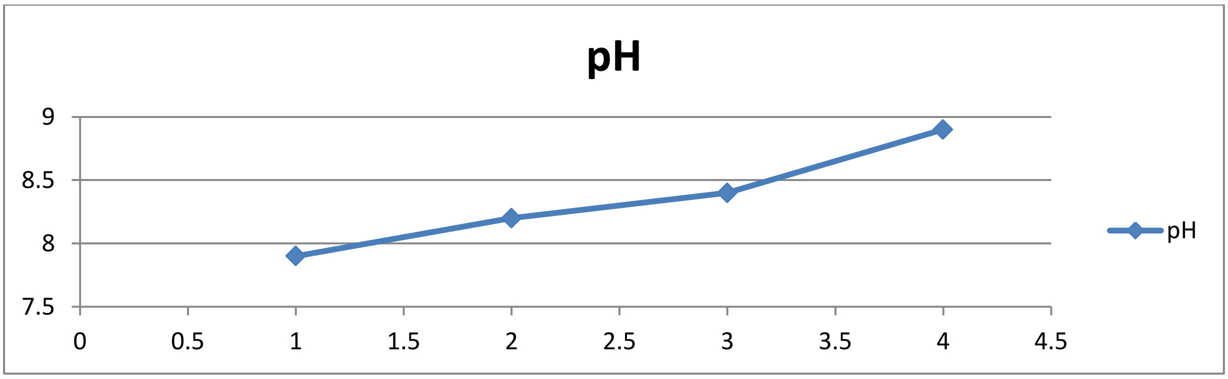
DISCUSSION:

Turbidity: From the results obtained from the analysis it was found that turbidity gets decreased mainly because of the upward flow of water. Due to upward flow of waste water all the minute impurities and large particles get trapped in the sludge blanket or are consumed by the microbial activity of the reactor.



(Fig. 5.4: decrease in turbidity with time)

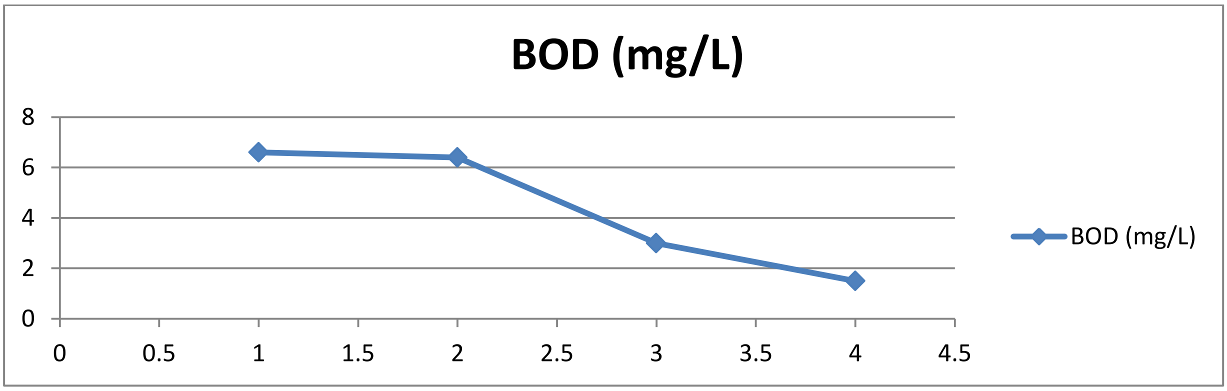
pH value: There was found to be a slight increase in pH value of the water samples from the reactor. The main reason behind this phenomenon is the formation of ammonia and ammonium salts from nitrogen by the nitrogen-fixing bacteria present in the sludge blanket which increases the alkalinity in the water.



(Fig. 5.5: increase in pH with time)

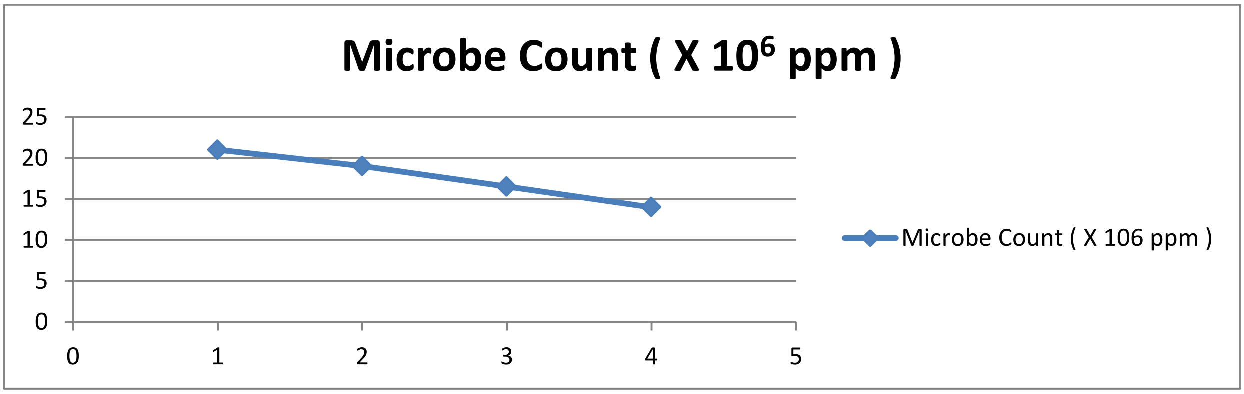
BOD concentration: It decreases with time because of the decomposition of organic compounds and pathogenic bacteria by micro-organism present in the sludge due to lack of these DO level does not decrease appreciably.

(Fig. 5.6: decrease in BOD with time)



Microbe Count: Since the reactor was operated in anaerobic conditions, without any supply of fresh sewage, the microbe concentration decreases with time in the absence of organic food. In a full scale operating treatment unit, there is a continuous supply of raw sewage and hence microbe concentration remains in equilibrium.

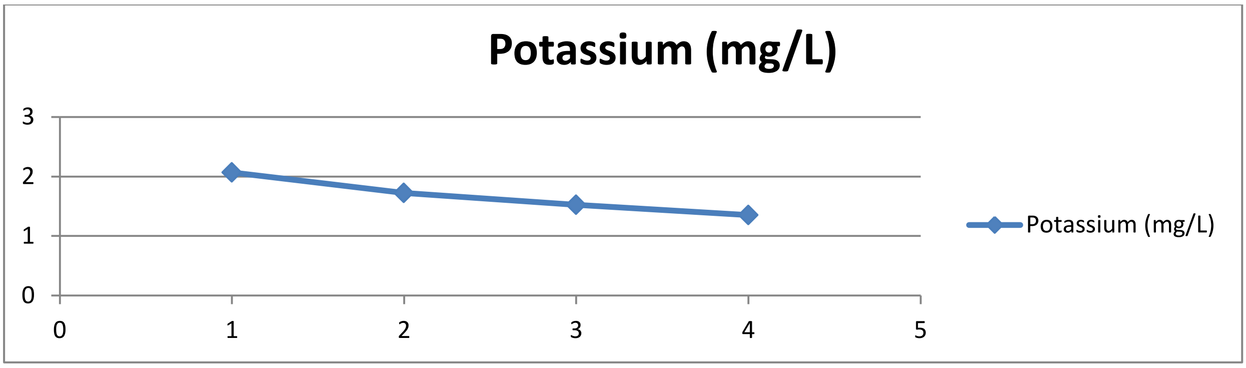
(Fig. 5.7: decrease in microbe count with time)



Heavy Metals: The concentration of heavy metals also decreases slightly with increase in retention time. The heavy metals present in the waste water samples are decomposed by the microbes which are later added to the sludge blanket. Therefore it is highly essential to remove the sludge regularly from the reactor in order to prevent intoxication of waste water from metals like lead, arsenic, potassium etc.

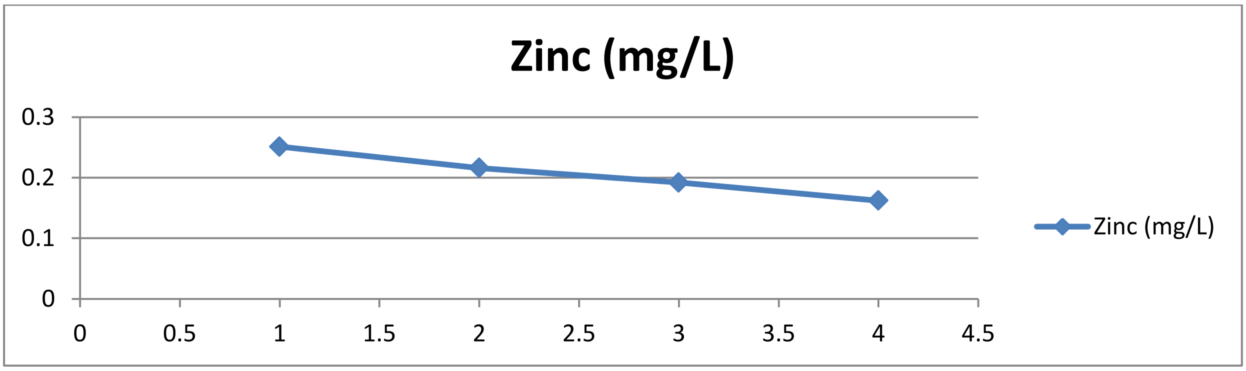
Potassium: Potassium deficiency may occur by the diffusion of hydrophobic ammonia molecule into the bacteria cell.

(Fig. 5.8: decrease in potassium concentration with time)



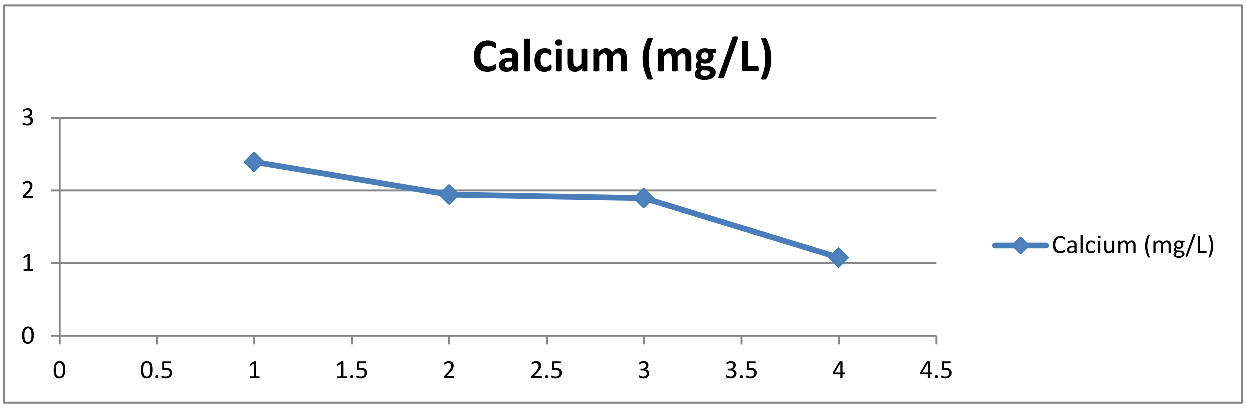
Zinc: The decrease in zinc is due to its reaction with a specific type of enzyme present in sludge called as Methanosarcina barkeri leading to the process of coenzyme –M activation. Thus it attributes to the decrease of zinc.it also settles as precipitate.

(Fig. 5.9: decrease in zinc concentration with time)



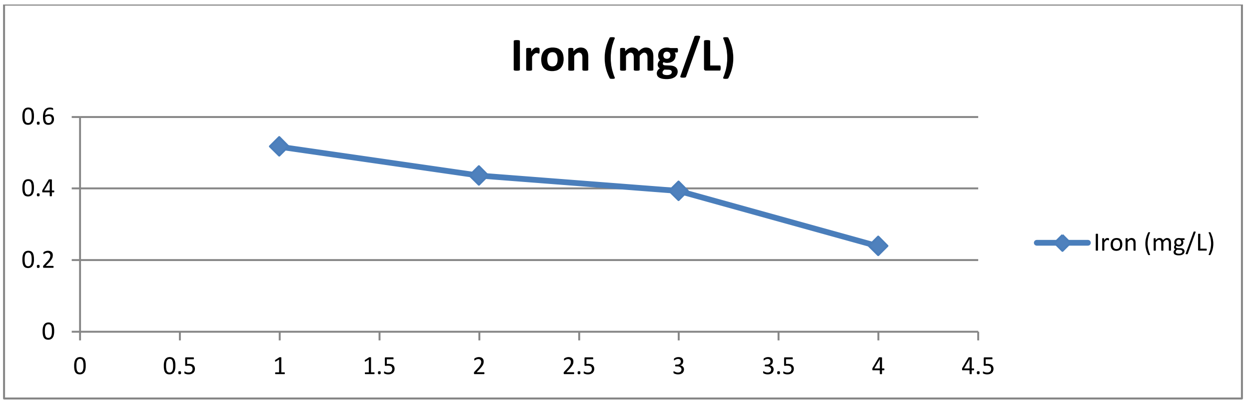
Calcium: Ammonia and sodium showed mutual antagonism, when each ion can antagonize the toxicity produced by another ion. As ammonia is produced in the reactor so its presence inhibits the production of calcium ions.

(Fig. 5.10: decrease in calcium concentration with time)



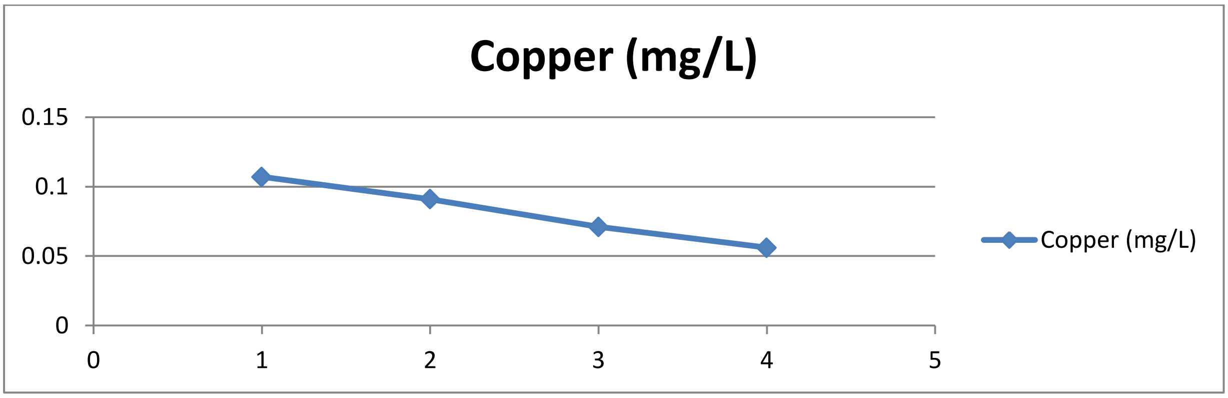
Iron: Iron help in formation of sludge granules and thus gets used up.It also gets precipitated along with heavier flocs .(Fang ,Tay ;2000)

(Fig. 5.11: decrease in iron concentration with time)



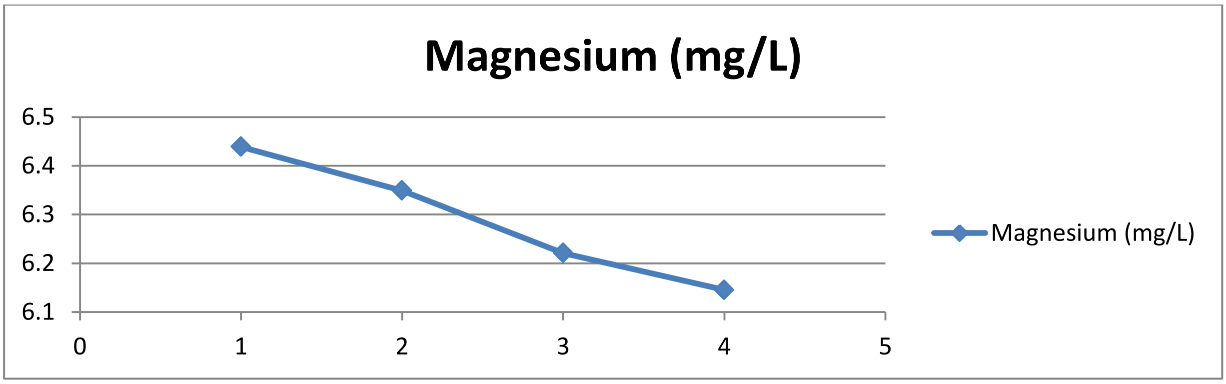
Copper: The novelty of this study relies on the significance of using two separate reactors, namely the upflow anaerobic sludge blanket (UASB) reactor and precipitator reactor. The substrates including glucose and sodium sulphate are left under anaerobic condition in the UASB reactor. While, the copper is used in the precipitator reactor. The UASB reactor reduces sulphate to hydrogen sulphide gas. Then, the biologically produced hydrogen sulphide gas was used for copper precipitation in the precipitator reactor.(BURAK,AZGUL ;2012)

(Fig. 5.12: decrease in copper concentration with time)



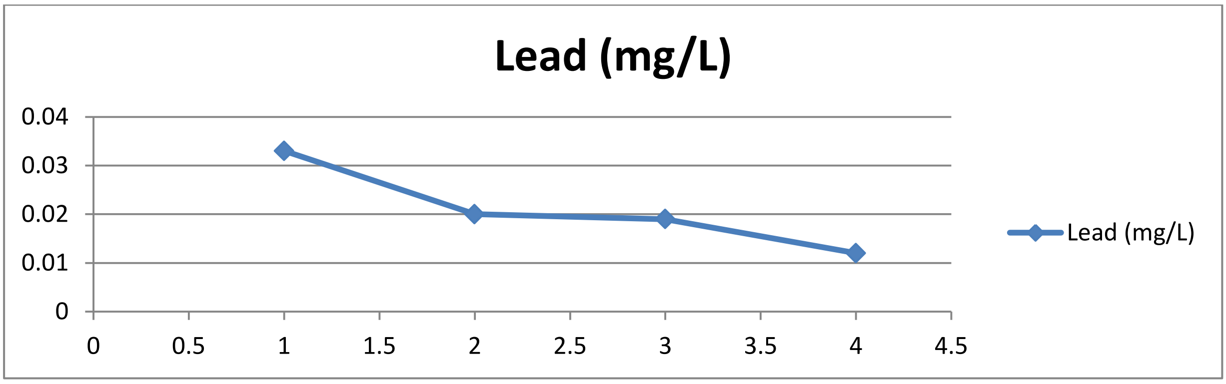
Magnesium: Ammonia and sodium showed mutual antagonism, when each ion can antagonize the toxicity produced by another ion. As ammonia is produced in the reactor so its presence inhibits the production of magnesium ions

(Fig. 5.13: decrease in magnesium concentration with time)



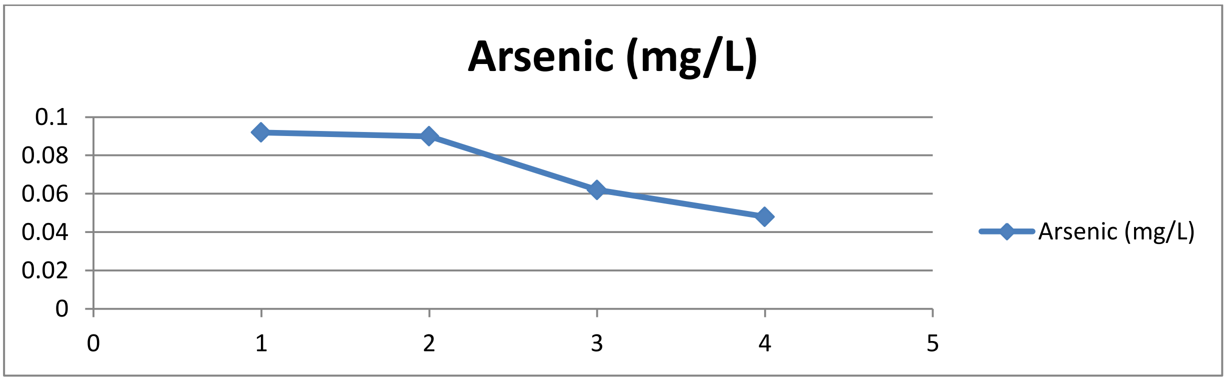
<u>Lead</u>: Lead decrease is mainly due to its decomposition by micro-organism ans also because of its absorption on the surface of flocs.

(Fig. 5.14: decrease in lead concentration with time)



Arsenic: Arsenic decrease is almost similar to that of lead. Its decrease mainly due to its decomposition by micro-organism and also because of its absorption on the surface of flocs .

(Fig. 5.15: decrease in arsenic concentration with time)



CHAPTER-6

CONCLUSION

7.1 Conclusions:

- The average ranges of physical, chemical and biological characteristics of waste water quality are experimented and found out and design of UASB was suitably done .
- Treated water found from UASB model shows following characteristics :

    1) Turbidity of treated water decreases with time and ranges from 57.1 to 37.6

    2) pH of treated water ranges increases with time and ranges from 7.9 to 8.9

    3) BOD of treated sample decreases with time and ranges from 6.6 to 1.5

- Concentration of metals decreases with time
- Total amount of treated water :1.365 ML/day

7.2 Dimensions of waste water treatment plant

- Diameter of collection pit is found to be 6m dia. and 5m depth
- Coarse screen of 5-6mm spacing is provided and fine screen of 1-3mm spacing is provided after coarse screen
- Rectangular sedimentation tank of 25m length ,3m wide and 3m height is provided
- A UASB treatment plant of 15m length, 9m wide and 3m height is provided.
- Sludge drying bed has length 6m, width 3m and height 1m.
- Secondary sedimentation tank of 20 m dia. is provided

CHAPTER-7

TIMELINE OF THE PROJECT

Time → / Work	August	September	October	November	December	January	February	March	April
Collection of data, literature study									
Collection of samples and characterization									
Fabrication and analysis of pilot UASB reactor									
Design of waste water treatment plant									
Report completion, thesis writing and thesis submission									

CHAPTER-8

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