DETERMINATION OF WASTE WATER CHARACTERSTICS OF NEARBY INDUSTRIES IN HIMACHAL PRADESH

B. Tech. Project

By

Abhinav Chauhan (111603)

Ankush Thakur (111621)

DEPARTMENT OF CIVIL ENGINEERING

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173234

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DETERMINATION OF WASTE WATER CHARACTERSTICS OF NEARBY INDUSTRIES OF HIMACHAL PRADESH

A PROJECT

Submitted in partial fulfilment of the requirements of award of the degree

of

BACHELOR OF TECHNOLOGY

By

Abhinav Chauhan (111603)

Ankush Thakur (111621)

Under the guidance of

Dr. RAJIV GANGULY

(Associate Professor)

DEPARTMENT OF CIVIL ENGINEERING

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173235

HIMACHAL PRADESH INDIA

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN HIMACHAL PRADESH INDIA

CANDIDATE'S DECLARATION

This is to certify that the work which is being presented in the project titled " **DETERMINATION OF WASTE WATER CHARACTERSTICS OF NEARBY INDUSTRIES IN HIMACHAL PRADESH"** in the partial fulfilment of the requirements for the award of Degree of Bachelor of Technology and submitted in Civil Engineering Department, Jaypee University Of Information Technology , Waknaghat, is an authentic record of work carried out by **Abhinav Chauhan**(111603) and **Ankush Thakur**(111621) during a period from August , 2014 to May, 2015 under the supervision of **Dr. Rajiv Ganguly,** Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date:………………..

Prof. Dr. Ashok Kumar Gupta	Dr. Rajiv Ganguly	………………
Professor & Head of Department	Associate Professor	External Examiner
Civil Engineering Department	Civil Engineering Department	
JUIT Waknaghat	JUIT Waknaghat	

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Abhinav Chauhan (111603)

Ankush Thakur (111621)

ABSTRACT

With the rapid growth of industries, pollution in natural waters by industrial wastes has increased tremendously. Due to lack of treatment and improper modes of disposal of wastes, he water bodies are polluted and they carry deadly substances. The present work aims at studying the natural effluent from different industries and hence to make a comparison of the quality of effluent water that are discharged into the waters system. Four effluent samples were collected from different industries and different physio-chemical parameters were analysed. The results were compared with WHO standards. The results are tabulated and conclusions are drawn. Then water quality index is calculated to evaluate the overall quality of water. Later principal component analysis was carried out to establish relation between the physio chemical parameters.

Key words : Effluent, Analysis, Physio-Chemical parameter, water samples, PCA and WQI.

CONTENTS

LIST OF ABBREVATIONS

1) COD : Chemical oxygen demand
2) BOD : Biological oxygen demand
3) DO : Dissolved oxygen
4) TDS : Total dissolved oxygen
5) NTU : Nephelometric Turbidity Units
6) WHO : World Health Organisation
7) BIS : Bureau Of Indian Standards
8) WQI : Water quality index
9) PCA : Principal component analysis

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CHAPTER 1

Introduction:

Industries use water for a variety of purposes such as – manufacturing goods, heating, cooling, as a carrier of raw material, as carrier of waste matter, as a solvent etc. The resulting water is then classified as waste water. Apart from industrial discharge, waste water can also be an end-product of municipal, agricultural activity. As such, the chemical composition of waste water naturally reflects the origin from which it came. In fact, the chemistry of waste water reflects to a very high degree the chemistry of life. It is perhaps the microbiology of waste water that presents the greatest concern to humanity from a public health stand point.

The continually increasing demand for water for beneficial purposes has forced man to assess and examine water reuse technologies more seriously then ever. Regardless of origin industrial wastewater, after proper treatment, represents another ample and reusable water source. Water pollution has been a major cause of concern to scientists and engineers. Water resource development has taken place all over the world. There is tremendous amount of pressure in protecting the water resources available in the world. Protecting the surface water resources from wastewater pollution plays a wider role for the development. He disposal of wastewater into the surface water bodies leads to serious problems and affects the people in health aspects. Especially in the urban areas, the pollution of domestic effluent discharges into nearby surface water bodies created problems for the public. There are many ways of safe disposal of wastewater. But improper management of wastewater generation in the urban areas find its own way of getting into the surface water. Hence the effluent discharge affects the surface water bodies.

The indiscriminate discharge of these waste water streams into the environment can render the soils sick, pollute the receiving bodies of water, cause air pollution by generating obnoxious gases. Discharge of untreated waste water into the domestic sewer system makes the task of treating domestic sewage a very difficult and costly activity. To prevent any health hazards caused by discharging waste water into the environment and protect domestic sewage, the waste water must be treated before discharge as per WHO prescribed permissible limits. So the industrial effluents are completely treated and then discharged into sewage or land. The present work is undertaken with the view to study the nature of effluent from different industries and hence to make a comparison of the quality of effluent water. A total of four samples were collected in the year 2014 from the following industries:

1. HPMC, fruit processing. (Parwanoo)
2. HIMFED, brewery. (Parwanoo)
3. Madhav BioTech Pvt Limited, pharmaceutical. (Solan)
4. Sai Printing Press, Printing. (Solan)

LITERAURE REVIEW:

Various past studies on the wastewater characteristics have been carried out to determine the effluent quality from different type of industries. These studies play a major role in the assessment of quality of the effluents from the industries and hence in determination of the extent of treatment to be provide for safe disposal. Some of the studies which have taken place in the past have been listed below.

1. Wastewater characterisation in urban areas: A case study of Aligarh studies, U.P, India (*J. Chem. Pharm. Res., 2011, 3(1): 685-697)*
    a. Wastewater quality of various lagoons and drains were analysed to identify the contaminated wastewater of the city. The samples of drain were collected from the inlet and discharge points and stored as per standard methods before analysing the physical and chemical parameters. All of the samples were tested for pH, chlorides, BOD, COD, TS, TSS, acidity, alkalinity and total hardness.
    b. The entire chemicals used in the study are laboratory grade. The water used in the study was distinguished and later double distilled and stored securely to avoid contamination. All the analysis was conducted according to standard method *(Standard Methods -2005).* The study is carried out at the room temperature which varies from 22-25ºC in winter time to 30-38ºC in summer time.
2. Study on Physico-Chemical parameters of wastewater effluents from Taloja industrial area of Mumbai, India. (*International Journal of Ecosystem, 2011; 1(1):1-9)*

    a. The study was carried at the Taloja industrial area which is one of the most rapidly developing and heavily polluted industrial belts of Mumbai. The industrial wastewater effluent samples were collected randomly twice in a month in morning, afternoon and evening session from different industries lie engineering industries, paper mills, fine chemical, manufacturing industries, dye industries of Taloja industrial belt. For each type of industry three representative units was selected. The samples were collected in polythene bottles. The bottles were cleaned and washed with tap water to render free of dirt, washed with distilled water and rinsed in water sample to be collected and then filled up the bottle with the sample leaving only a small air gap at the top. The sample bottles were sealed.

b. The samples collected were analysed for temperature, TS, TDS, TSS, chloride content, BOD and COD values. The techniques and methods followed for collection, preservation, analysis and interpretations.

OBJECTIVE OF WORK:

1) To calculate all those parameters which are necessary for the evaluation of wastewater. These include parameters like BOD, COD, TDS, etc. All these parameters are determined in the laboratory as per the laid specifications and standards methods for determination is done.
2) Comparison of the observed parameters with the guidelines set by different institute like WHO BIS is done to determine the extent of contamination of the water.
3) To calculate the water quality index as per the guidelines of BIS.
4) To carry out the principal component analysis of the waste water on the basis of WQI and physio-chemical parameters and establish the relation between them.

CHAPTER 2

STUDY AREA

The industrial waste water samples were taken from these industries was taken from the Solan district:

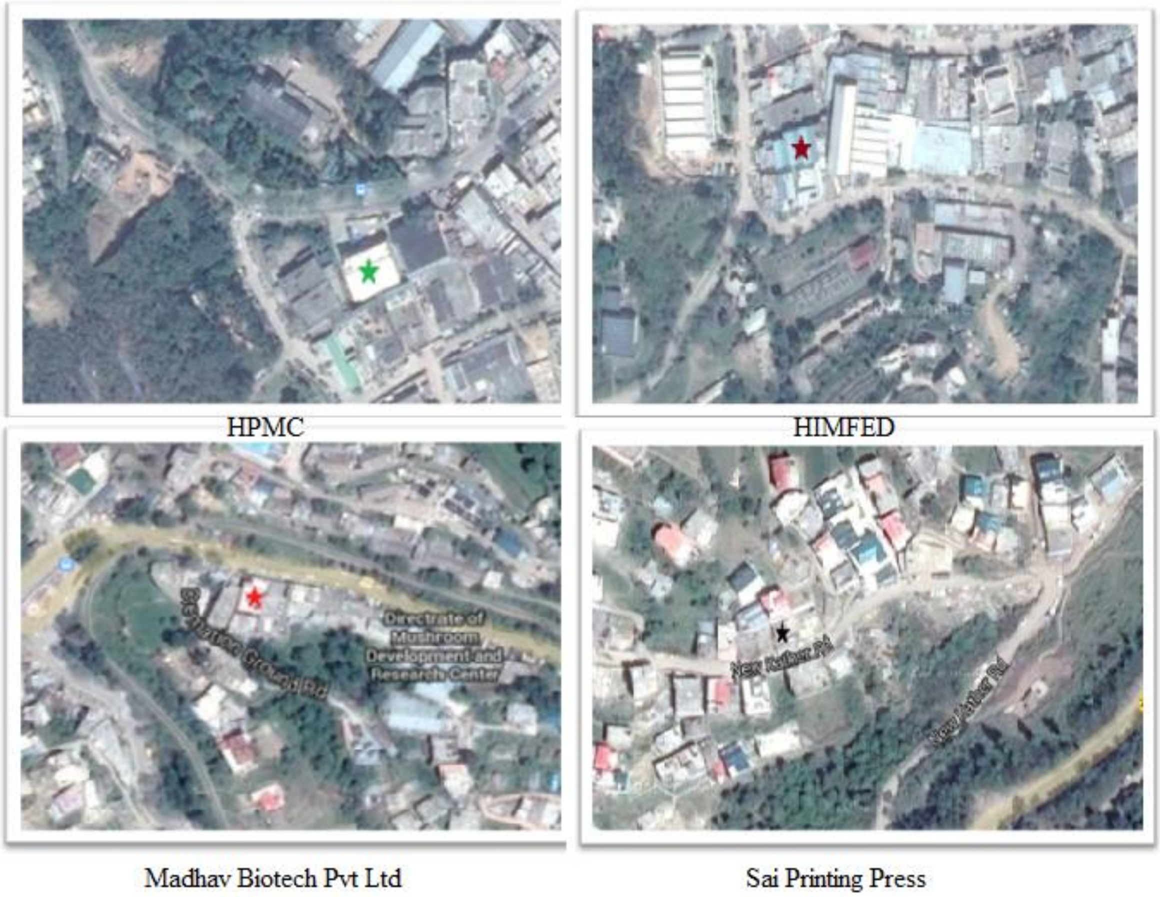


Fig. 2.1 Locations of industries

HPMC

HPMC was established in the year 1974 as state public undertaking with the objective of marketing of fresh fruits and all types of surplus fruits. It is the main producer of apple juice concentrate. Besides it all also produces concentrate of orange, pear, plum and strawberry.

HIMFED

HIMFED was registered on 30th June 1952 under the provision of Indian Cooperative Societies Act.The HIMFED undertakes multifarious activities to serve the farming community and the consumers of the state by marketing of farm inputs. The HIMFED bottling unit on Parwanoo undertakes the production of liquor.

Madhav Biotech Pvt Ltd

The company was established in 1999. The company has a manufacturing unit based at Solan, HP. The company uses the latest pharmaceutical technology to fulfil the needs of its customers.The company has over 200 products i.e. tablets, capsules, syrups, injections, ointments and protein powders.

Sai printing press

Sai Printing press was established in Solan district of Himachal Pradesh in year 2004.Their main business covers the printing of ingredients and other important information on various pharmaceutical drugs.They also print on the packaging of medicines and drugs.

CHAPTER 3

SAMPLING TECHNIQUE USED

A sampling can be done in two ways. These are:

a) **Grab sampling: (**SP Gautam, (2007) *Guide Manual Of Water and Waste Water Analysis)*

Grab samples are single collected at a specific spot at a site over a short period of time (typically seconds or minutes). Thus, they represent a snapshot in both space and time of a sapling area. Discrete grab samples are taken at selected location, depth, time. (

Advantages:

1. It provides an immediate sample and thus is preferred.
2. These are very appropriate to small plants with low flows and where limited staff is available.

Disadvantages:

1. Grab sample takes snapshot of characteristic of water at specific point and time, so it may not be completely representative of entire flow.

b) **Composite sampling: (**SP Gautam, (2007) *Guide Manual Of Water and Waste Water Analysis)*

Composite samples provide a more representative sampling of heterogeneous matrices in which the concentration of the analytes of interest may vary over short period of time or space. They are obtained by combining portions of multiple grab samples or by using specially designed automatic sampling devices. Sequential composite samples are collected by mixing equal water volumes collected at regular time intervals.

Advantages:

1. It includes reduced costs of analyzing large number of samples, more representative samples of heterogeneous matrices.
2. They give the snapshot of entire water sample.

Disadvantages:

1. It is a time consuming process and requires more staff.
2. It is not suitable where the analytes to be determined are not to be provided storage like temperature determination.

REASONS FOR GRAB SAMPLING:

Grab sampling is generally done when there is lack of time or staff to carry out the composite sampling. As the sites were far from our institute we had to restrict ourselves to grab sampling as it was not feasible to take samples after given interval from a single effluent source.

CHAPTER 4

LIST OF EXPERIMENTS PERFORMED

We have conducted the following lists of experiments in the laboratory using the guidelines specified for experiments on waste water *(Standard Methods-2005)* and find out the characteristics of effluent coming from different types of industries.

S,NO	LIST OF EXPERIMENTS
1	To determine pH of waste water samples.
2	To determine specific conductivity of waste water samples.
3	To determine total solids of waste water samples.
4	To determine total dissolved solids of waste water samples.
5	To determine total suspended solids of waste water samples.
6	To determine turbidity of waste water samples.
7	To determine acidity of waste water samples.
8	To determine the alkalinity of waste water samples.
9	To determine the concentration of chlorides in the waste water samples.
10	To determine DO of waste water samples.
11	To determine the BOD of waste water samples.
12	To determine the COD of waste water samples.

NAME OF EXPERIMENT: pH

AIM: To determine pH of waste water samples.

PRINCIPLE:

pH value denotes hydrogen ion concentration in the liquid and it is the measure of acidity or alkalinity of the liquid. According to law of mass action, in any liquid

Concentration of H ions × Conc. of OH ions/Conc. of undissolved HOH molecules

$$= \text{constant} = 10^{-14}$$

For convenience pH scale is taken from 0 to 14

pH of sample determined by using:

pH papers.

APPARAUS: pH Strips.

PROCEDURE:

1. Dip a wide range pH strip into the solution whose pH o be found. The colour of litmus paper changes to thick red for highly acidic waters to dark green for highly alkaline waters and to any other colour depending on ph of solution. Compare the colour of paper with standard colours supplied.

pH meter

1. Switch on the pH meter on for 15 minutes.
2. After washing pH electrode and temperature probe is dipped in solution of pH 4.0 buffer. Change knob from standby to pH.
3. With CAL knob set the pH value to 4.0.
4. With pH 9.2 buffer, set the value to 9.2 using SLOPE knob.
5. Repeat the steps till pH meter standardized.
6. Take pH of different samples.
7. Note down the temperature.

We have used pH meter as it does not give stable values but within a range corresponding to results from pH paper

SIGNIFICANCE: The determination of range of pH is necessary for waste water because certain coagulants work best under some range of pH. Coagulants work best under certain ph range and thus the determination of pH becomes necessity. Also while providing the biological treatment to water certain bacteria work best under fixed pH range. Thus pH determination is very important for waste water.

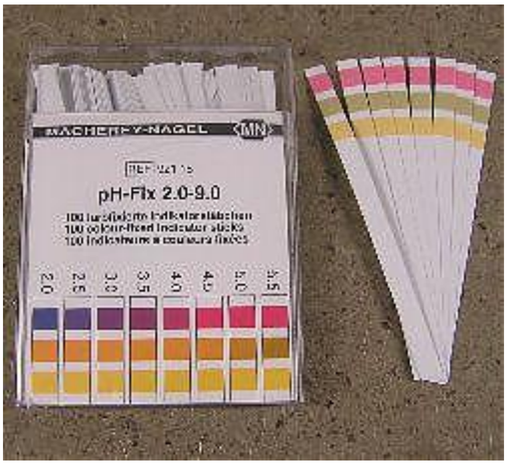


Fig. 4.1 pH paper

NAME OF EXPERIMENT: SPECIFIC CONDUCTIVITY

AIM: To determine specific conductivity of waste water sample.

PRINCIPLE: The electrical conductivity is a total parameter for dissolved substances. Its value depends on concentration and degree of dissociation of the ions as well as temperature and migration velocity of ions in electrical field.

APPARATUS: Conductivity meter, beakers.

PROCEDURE:

1. Switch on the conductivity meter for 15 minutes
2. Take out the conductivity cell dipped in distilled water, wash it with distilled water and wipe it dry with a tissue paper.
3. Calibrate the cell with standard 0.1N KCl solution of conductivity 14.12 m mhos at 25ºC.
4. Take out the conductivity cell, wash it thoroughly with distilled water and wipe it dry.
5. Dip the cell into the sample solution, swirl the solution and wait up to 1minute for a steady reading.
6. Note down the instrument reading and also temperature.

SIGNIFICANCE: Changes in conductivity could be an indicator that a discharge or some other source of pollution has entered the stream. Higher value of conductivity indicates the presence of chlorides.

Fig. 4.2 Conductivity meter

NAME OF EXPERIMENT: TOTAL SOLIDS

AIM: To determine total solids of waste water samples.

PRINCIPLE: Total solids are determined as the residual left after evaporation & drying of unfiltered sample.

APPARATUS:

1. Evaporating dish.

2. Oven

3. Water bath

PROCEDURE:

1. A clean porcelain dish is ignited in a muffle furnace and after partial cooling in the air it is cooled and weighted.
2. A 100ml of well mixed sample is placed in the dish and evaporated at 100ºC on water bath, followed by drying in oven at 103ºC for one hour
3. Dry to a constant weight at 103ºC, cool and weigh.

SIGNIFICANCE: Solids analysis are important in the control of biological and physical waste water treatment processes and for accessing compliance with regulatory agency waste water affluent limitations. The amount of solids in waste water is frequently used to describe the strength of the water. Higher concentration of solids can serve as carrier of toxics.

NAME OF EXPERIMENT: TOTAL DISSOLVED SOLIDS

AIM: To determine total dissolved solids of waste water samples.

PRINCIPLE: It is determined as the residue left after evaporation and drying of filtered water sample.

APPARATUS:

1. Evaporating dishes

2. Oven

3. Whatman Filter paper No. 44 (0.45 micron)

PROCEDURE:

1. A clean porcelain dish is ignited in a muffle furnace and after partial cooling in the air, it is cooled at weighted.
2. A 100ml of filtered sample is placed in the dish and evaporated at 100ºC on water bath followed by drying in oven at 103ºC for 24 hour.
3. Dry to a constant weight at 103ºC, cool and weigh.

SIGNIFICANCE: Many industrial wastes contain unusual amount of dissolved inorganic salts and their presence can be easily detected. TDS is a measure of amount of material dissolved in water. This material can include chloride and other ions. Changes in TDS concentrations can be harmful because the density of water determines the flow of water into and out of an organism cells.

NAME OF EXPERIMENT: TOTAL SUSPENDED SOLIDS

AIM: To determine total suspended solids of waste water samples.

PRINCIPLE: It is determined as the residue left on evaporating dishes after drying in oven.

APPARATUS:

1. Evaporating dishes

2. Oven

SIGNIFICANCE:

1. This test serves as the principal basis of determining whether primary sedimentation facilities are required for treatment. High TSS can cause an increase in surface water temperature because the suspended particle absorbs heat from sunlight. This can cause decrease in DO level.

Fig. 4.3 Oven

Fig. 4.4 Filter Paper

NAME OF EXPERIMENT: TURBIDITY

AIM: To determine turbidity of waste water sample.

PRINCIPLE: When light passes through a sample having suspended particles some of the light is scattered by the particles. The scattering of light is generally proportional to the turbidity. Turbidity of sample is thus measured from the amount of light scattered by the sample taking the reference with standard turbidity solution.

APPARATUS:

Nephelometric Turbidity meter, Sample tubes.

REAGENTS:

1. Dissolve 1g of Hydrazine sulphate and dilute to 100ml.
2. Dissolve 10g of hexamethylene tetra amine and dilute to 100 ml.
3. Mix 5ml of each of the above solution in a 100ml volumetric flask and allow standing for 24 hours a 25ºC and diluting to 1000ml. This solution has a turbidity of 40 NTU.

PROCEDURE:

1. Switch on the Nephelometric turbidity meter and wait for few minutes till it warm up.
2. Set the instrument at 100 on the scale with a 40 NTU standard suspension. In this case every division on the scale will represent (0.4) NTU turbidity.
3. Shake thoroughly the sample and keep it for some time to eliminate he air bubbles.
4. Take sample in Nephelometer sample tube and put the sample in sample chamber and find out the value on the scale.
5. Dilute the sample with turbidity free water and again read the turbidity

SIGNIFICANCE: Turbidity in water is caused primarily suspended solids. Higher the turbidity more is the concentration of suspended solids in water. High turbidity can interfere with disinfection and provide a medium for microbial growth

.

Fig. 4.5 Turbidity meter

NAME OF THE EXPERIMENT: ACIDITY

AIM: To determine acidity of waste water samples.

PRINCIPLE: The mineral acids present in the sample which are contributing mineral acidity can be calculated by titrating on neutralizing the samples with strong base NaOH to pH4.3. The CO_2 and bicarbonates present can contribute CO_2 acidity in the sample and can be neutralized completely by continuing the titration to pH 8.2.

APPARATUS: Burette, Pipettes, Conical Flask

REAGENTS REQUIRED:

1. Standard sodium hydroxide
2. Phenolphthalein indicator
3. Methyl orange indicator
4. Sodium thiosulphate
5. Carbon free distilled water

PROCEDURE:

1. Pipette out 100 ml of the given water sample into a conical flask
2. Add 1 drop of 0.1N sodium thiosulphate solution to destroy any residual chlorine
3. Add 2 drops of methyl orange indicator. The sample turns pink.
4. Titrate against 0.02N standard sodium hydroxide solution until pink colour changes to yellow.
5. Note down the volume of the NaOH added.
6. Take another conical flask containing 100 ml of water sample, add 2 drops of phenolphthalein.
7. Proceed with titration until the sample turns pink.
8. Note down the total volume of NaOH added.

SIGNIFICANCE: Industrial wastewater containing high mineral acidity must be neutralized before they are subjected to biological treatment or discharged to water sources.

NAME OF EXPERIMENT: ALKALINITY

AIM: To determine the alkalinity of waste water samples.

PRINCIPLE: Alkalinity can be obtained by neutralizing OH^- , CO_3^{--} and HCO_3^- with standard H_2SO_4. Titration to pH 8.3 or decolourization of phenolphthalein indicator will show complete neutralization of OH^- and half of CO_3^{--}, while to pH 4.4 sharp changes from yellow to pink of methyl orange indicator will indicate total alkalinity.

APPARATUS: Burette, Pipettes, Conical Flask

REAGENTS REQUIRED:

1. Standard sulphuric acid
2. Phenolphthalein indicator
3. Methyl orange indicator
4. Carbon dioxide free distilled water
5. Sodium thiosulphate

PROCEDURE:

1. Take 100 ml of the given water sample in a conical flask.
2. Add one drop of 0.1N sodium thiosulphate solutions to remove the free residual chlorine if present.
3. Add 2 drops of phenolphthalein indicator. The sample turns pink.
4. Run down .02N standard sulphuric acid till the solution turns colourless.
5. Note down the volume of sulphuric acid added.
6. Add 2 drops of methyl orange indicator till the sample turns yellow.
7. Resume titration till the colour of solution turns to pink.
8. Note down the total volume of sulphuric acid added.

SIGNIFICANCE: The alkalinity acts as a pH buffer in coagulation and lime-soda softening of water.In waste it is an important factor in determining amenability of wastes to the treatment process and control of process such as anaerobic digestion.

NAME OF THE EXPERIMENT: CHLORIDES

AIM: To determine the concentration of chlorides in the waste water samples.

PRINCIPLE: The Mohr method for the determination of chloride in water is based upon the fact that in solution containing chloride and chromate, silver reacts with all the chlorides and precipitates before the reaction with chromate begins. The appearance of brick red colour of the silver chromate precipitate is the end point of titration.

APPARATUS: Burette, Pipette and conical Flask.

REAGENTS:

1. Chloride free distilled water.
2. Potassium chromate colour indicator
3. Standard silver nitrate solution
4. Standard sodium chloride solution

PROCEDURE:

1. Take 100 ml of sample in conical flask.
2. Adjust the pH between 7.0 to 8.0 either with sulphuric acid or sodium hydroxide solution.
3. Add 1 ml of potassium chromate indicator to get light yellow colour.
4. Titrate with standard nitrate silver nitrate solution till the colour changes from yellow to brick red.
5. Note the volume of silver nitrate added.
6. For better accuracy, titrate 100 ml of distilled water in the same way after adding 1 ml of potassium chromate indicator to establish reagent blank.
7. Note the volume of silver nitrate added for distilled water.

BLANK TITRATION:

1. Take 20 ml of distilled water in a clean 250ml conical flask.
2. Add 1ml of potassium chromate indicator to get light yellow colour.
3. Titrate he sample against silver nitrate solution until the colour changes from yellow to brick red.
4. Note the volume of silver nitrate added.

SIGNIFICANCE: Determination of disinfectant demand of waste water is important consideration in design. It serves as the basis for determining the capacity of disinfection required, the amount of disinfectant needed.

NAME OF EXPERIMENT: DISSOLVED OXYGEN

AIM: To determine DO of waste water samples.

PRINCIPLE: The principle involved in determination of DO is to bring about oxidation of potassium iodide to iodine with the dissolved oxygen present in the water sample after adding $MnSO_4$, KOH &KI, and the basic manganic oxide formed acts as an oxygen carrier to enable dissolved oxygen to take part in reaction.

The liberated iodine is titrated against standard sodium thio-sulphate solution using starch as a indicator. The blue colour disappears gives indication of dissolved oxygen present originally.

THEORY: Determination of DO is important as it indicates purity of water. DO is needed for living organism to maintain their biological processes. If DO is less than required limit there is indication of pollution due to industrial waste. This test helps us to assess check on stream pollution. Oxygen is poorly soluble in water. The solubility of DO decreases with increase in concentration of salts at 1 atmospheric pressure.

APPARATUS: BOD bottles, Pipettes, Burette

REAGENTS REQUIRED:

1. Standard sodium thio-sulphate solution (0.02N),
2. KMnO4 solution (N/10),
3. Potassiun oxalate solution (2%),
4. Manganous sulphate solution (4.8%),
5. Alkaline potassium iodide,
6. Freshly prepared starch solution,
7. Concentrated sulphuric acid

PROCEDURE:

1. Collect sample in a BOD bottle using Do sampler.
2. Add 0.9mL H_2SO_4 followed by 0.2mL of $KMnO_4$ reagent to a sample collected in 250 to 300mL bottle up to the brim. The tip of the pipette should be below the liquid level while adding these reagents. Rinse the pipettes before putting them to reagent bottles.
3. Add 0.5 ml of potassium oxalate solution, and mix well.

4. Now add 2ml of $MnSO_4$ solution followed by 3 ml of alkaline KI solution. Stopper and shake and allow the precipitate to settle.
5. Now add 1 ml of conc. H_2SO_4solution and mix until the precipitate is completely dissolved.
6. Measure 102.2 ml of this solution with measuring and titrate it against (N/50) hypo solution.
7. When colour of the solution is very light yellowish add 2ml of freshly prepared starch solution and continue the titration to the disappearance of the blue colour.

SIGNIFICANCE: DO measurements are vital for maintaining aerobic condition in waste water that receives pollution matter and in aerobic treatment process intended to purify industrial waste water. Determination of DO of waste water serve as the basis of the BOD test, thus they are used to evaluate pollution strength of industrial wastes.

NAME OF THE EXPERIMENT: BIOLOGICAL OXYGEN DEMAND (BOD)

AIM: To determine the BOD of waste water samples.

PRINCIPLE: The BOD is an imperial biological test this BOD may be considered as wet oxidation procedure in which the living organisms serve as the medium for oxidation of the organic matter to CO_2 and water.

INTERFERENCE: Undesirable oxygen consumption via nitrification can be prevented by addition of an N-allyl-thio-urea solution. Free chlorine present in some waste waters after chlorination reacts with organic components within about 2hrs and does not interfere. Compounds which use up oxygen without the presence of microorganisms are oxidized by leaving the original sample for 2hrs with occasional shaking. Lack of nutrients in diluted water, lack of an acclimaed seed organisms and the presence of toxic substances can result in very low BOD values, despite the presence of sufficient degradable organic materials.

REAGENTS:

1. Distilled water.
2. Magnesium Sulphate solution.
3. Sodium thio-sulphite solution.
4. Calcium chloride solution
5. Phosphate buffer solution.

PROCEDURE:

1. Place the desired volume of distilled water in a 300 ml flask. Aeration is done by bubbling compressed air through water.
2. Add 1 ml of phosphate buffer, 1 ml of magnesium sulphate solution, 1ml of calcium chloride solution and 1ml of ferric chloride solution for every litre of distilled water (dilution water).
3. In the case of wastewaters which are not expected to have sufficient bacterial population, add seed o the dilution water. Generally 2ml of settled sewage is sufficient for 1000ml of dilution water.
4. Highly acidic or alkaline samples are to be neutralised to a pH of 7.
5. Add 2-3 ml of sodium thiosulphate solution to destroy residual chlorine if any.
6. Dilute the sample with the distilled water and mix he contents well.

7. Take diluted sample in 2 BOD bottles.
8. Fill another two bottles with diluted water alone.
9. Immediately find D.O of a diluted waste water and diluted water.
10. Incubate the other BOD bottles at 200ºC for 5 days. They are to be tightly stoppered to prevent any air entry into the bottles.
11. Determine D.O content in the incubated bottles at the end of 5 days.

SIGNIFICANCE: Information concerning BOD of wastes is an important consideration in design of treatment facilities. It is a factor which is used to determine the design of certain units, particularly trickling filters and activated sludge units. This test is used to evaluate the efficiency of various treatment processes.

Fig. 4.6 BOD Incubator

NAME OF THE EXPERIMENT: CHEMICAL OXYGEN DEMAND (COD)

AIM: To find out the COD of waste water samples.

PRINCIPLE: The organic matter present in sample get oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 to produce CO_2 and H_2O the excess $K_2Cr_2O_7$ remaining after the reaction is titrated with $Fe(NH_4)_2(SO_4)_2$. The dichromate consumed gives the oxygen required to oxidatize the organic matter.

REAGENTS:

1. Standard Potassium dichromate 0.25N
2. Sulphuric acid with reagent (conc.H_2SO_4 + Ag_2SO_4)
3. Standard ferrous ammonium sulphate 0.1 N
4. Ferroin indicator.
5. Mercuric Sulphate.

PROCEDURE:

1. Place 0.4 gm of sulphuric acid in the reflux flask.
2. Add 20 ml of sample.
3. 10 ml of more concentrated dichromate solution are placed into flask together with glass beds.
4. Add slowly 30 ml of sulphuric acid containing Ag_2SO_4 and mix thoroughly.
5. Connect he flask to condenser. Mix the contents thoroughly before heating. Improper mixing results in bumping and the sample may be blown out.
6. Open reflux for a minimum period of 2 hours. Cool and wash down the condenser with distilled water.
7. Dilute the sample to make up 150 ml and cool.
8. Titrate excess $K_2Cr_2O_7$ with 0.1N $Fe(NH_4)_2(SO_4)_2$using ferroin indicator, sharp colour change from blue green to wine red indicates the end point.
9. Reflux the blank in the same manner using distilled water instead of sample.

SIGIFICANCE: COD is useful to assess strength of wastes, which contain toxins and biologically resistant organic substances.The ratio of BOD to COD is useful to assess the amenability of the waste for biological treatment. Ratio of BOD to COD greater than or equal to 0.8 indicates that wastewaters are highly amenable to the biological treatment.

Fig. 4.7 Spectrophotometer

Fig. 4.8 COD reactor

CHAPTER 5

TEST RESULTS

The test results carried out on raw effluents are tabulated in the table below:

Name of experiment	HPMC	HIMFED	MADHAV Biotech	SAI PRINTING PRESS
pH	7-8	7-8	7-8	8-9
Total solids	240 mg/l	220 mg/l	700 mg/l	5200 mg/l
Suspended solids	20 mg/l	120 mg/l	500 mg/l	1900 mg/l
Turbidity	2 NTU	9 NTU	84 NTU	700 NTU
Conductivity	0.325 mmho/cm	0.33 mmho/cm	0.52 mmho/cm	1.04 mmho/cm
Alkalinity	200 mg/l	170 mg/l	310 mg/l	550 mg/l
Acidity	12 mg/l	16 mg/l	60 mg/l	85 mg/l
Chloride Content	24.2 mg/l	97.15 mg/l	48.5 mg/l	70 mg/l
Chemical oxygen demand	36 mg/l	329 mg/l	753 mg/l	926 mg/l
Biological oxygen demand	23.5 mg/l	206 mg/l	225 mg/l	189 mg/l
Dissolved oxygen	8 mg/l	7.5 mg/l	6 mg/l	5.8 mg/l

Table 5.1

Table below shows comparison of results with respect to WHO & ISI Standards:

HPMC

Name of experiment	HPMC	WHO TEST STANDARDS	ISI STANDARDS
pH	7	6-9	5.5-9
Total solids	240 mg/l	200 mg/l	200 mg/l
Suspended solids	20 mg/l	100 mg/l	100 mg/l
Turbidity	2 NTU	NA	NA
Conductivity	0.325 mmho/cm	1 mmho/cm	1 mmho/cm
Alkalinity	200 mg/l	NA	NA
Acidity	12 mg/l	NA	NA
Chloride Content	24.2 mg/l	600 mg/l	1000 mg/l
Chemical oxygen demand	36 mg/l	150 mg/l	250 mg/l
Biological oxygen demand	23.5 mg/l	100mg/l	350 mg/l
Dissolved oxygen	8 mg/l	6 mg/l (min)	4 mg/l (min)

Table 5.2

HIMFED

Name of experiment	HIMFED	WHO TEST STANDARDS	ISI STANDARDS
pH	7	6-9	5.5-9
Total solids	220 mg/l	200 mg/l	200 mg/l
Suspended solids	120 mg/l	100 mg/l	100 mg/l
Turbidity	9 NTU	NA	NA
Conductivity	0.33 mmho/cm	1 mmho/cm	1 mmho/cm
Alkalinity	170 mg/l	NA	NA
Acidity	16 mg/l	NA	NA
Chloride Content	97.15 mg/l	600 mg/l	1000 mg/l
Chemical oxygen demand	329 mg/l	150 mg/l	250 mg/l
Biological oxygen demand	206 mg/l	100 mg/l	350 mg/l
Dissolved oxygen	7.5 mg/l	6 mg/l (min)	4 mg/l (min)

Table 5.3

MADHAV BIOTECH

Name of experiment	MADHAV Biotech	WHO TEST STANDARDS	ISI STANDARDS
pH	7	6-9	5.5-9
Total solids	700 mg/l	2100 mg/l	200 mg/l
Suspended solids	500 mg/l	100 mg/l	100 mg/l
Turbidity	84 NTU	NA	NA
Conductivity	0.52 mmho/cm	1 mmho/cm	1 mmho/cm
Alkalinity	310 mg/l	NA	NA
Acidity	60 mg/l	NA	NA
Chloride Content	48.5 mg/l	600 mg/l	1000 mg/l
Chemical oxygen demand	753 mg/l	250 mg/l	250 mg/l
Biological oxygen demand	225 mg/l	100 mg/l	350 mg/l
Dissolved oxygen	6 mg/l	6 mg/l (min)	4 mg/l (min)

Table 5.4

SAI PRINITING PRESS

Name of experiment	SAI PRINITING PRESS	WHO TEST STANDARDS	ISI STANDARDS
pH	8	6-9	5.5-9
Total solids	5200 mg/l	2100 mg/l	200 mg/l
Suspended solids	1900 mg/l	100 mg/l	100 mg/l
Turbidity	700 NTU	NA	NA
Conductivity	1.04 mmho/cm	1 mmho/cm	1 mmho/cm
Alkalinity	550 mg/l	NA	NA
Acidity	85 mg/l	NA	NA
Chloride Content	70 mg/l	600 mg/l	1000 mg/l
Chemical oxygen demand	926 mg/l	250 mg/l	250 mg/l
Biological oxygen demand	189 mg/l	100 mg/l	350 mg/l
Dissolved oxygen	5.8 mg/l	6 mg/l (min)	4 mg/l (min)

Table 5.5

GRAPHICAL REPRESENTATION OF WASTE WATER CHARACTERISTICS FROM DIFFERENT INDUSTRIES AND COMPARISON WITH WHO & ISI STANDARDS:

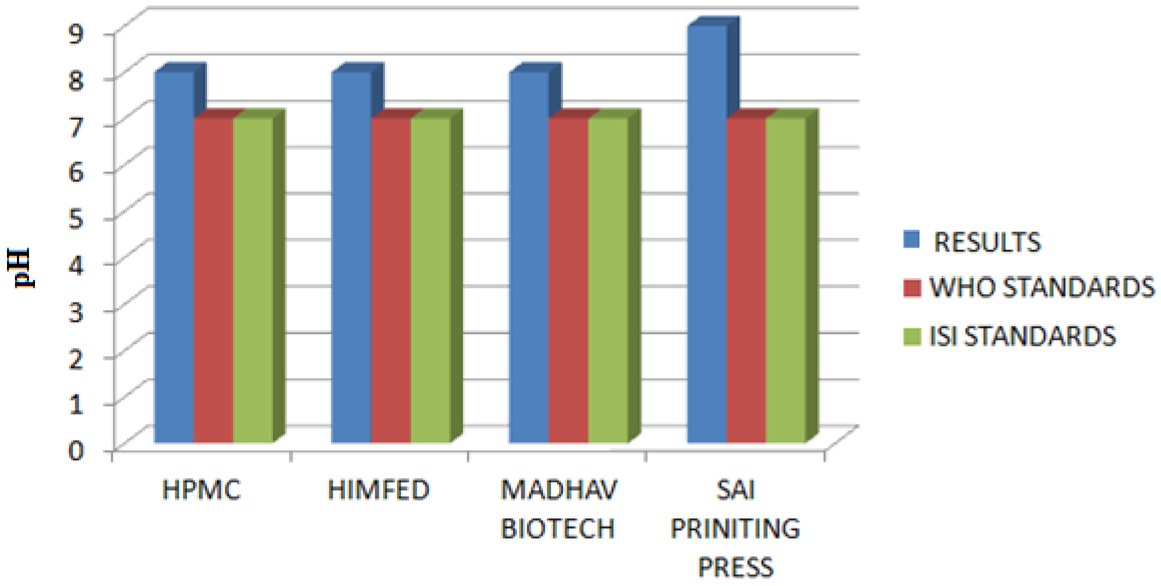


Fig. 5.1

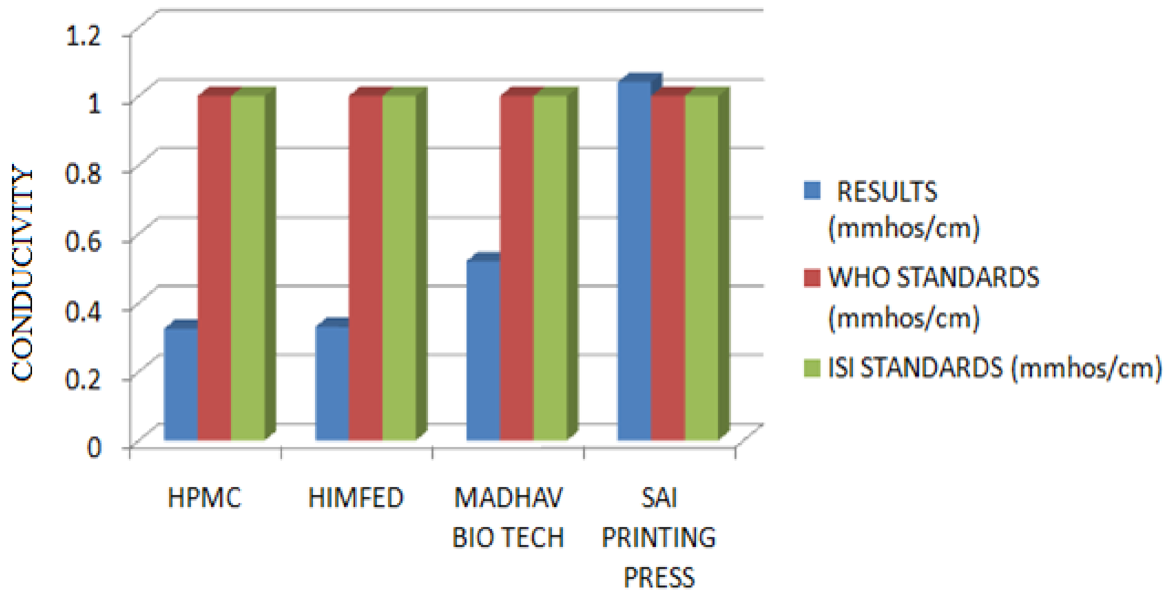
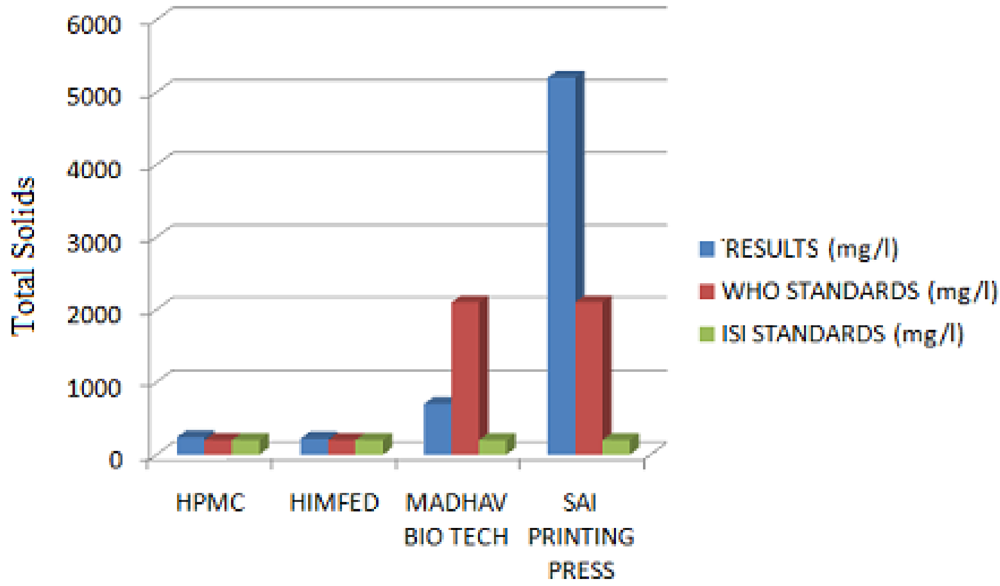
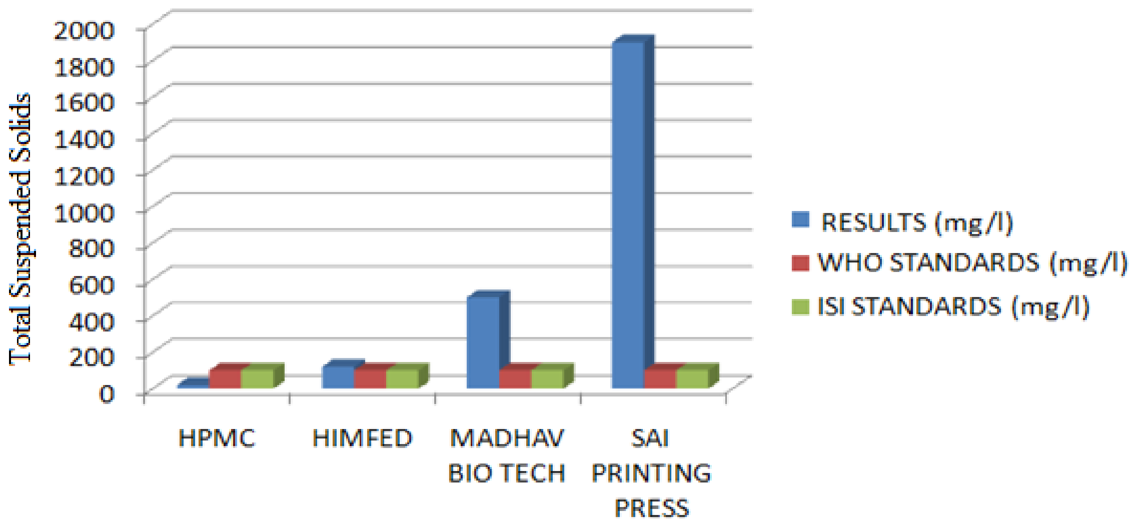


Fig. 5.2



Total Solids
6000
5000
4000
3000
2000
1000
0
HPMC
HIMFED
MADHAV BIO TECH
SAI PRINTING PRESS
RESULTS (mg/l)
WHO STANDARDS (mg/l)
ISI STANDARDS (mg/l)

Fig. 5.3



Total Suspended Solids
2000
1800
1600
1400
1200
1000
800
600
400
200
0
HPMC
HIMFED
MADHAV BIO TECH
SAI PRINTING PRESS
RESULTS (mg/l)
WHO STANDARDS (mg/l)
ISI STANDARDS (mg/l)

Fig. 5.4

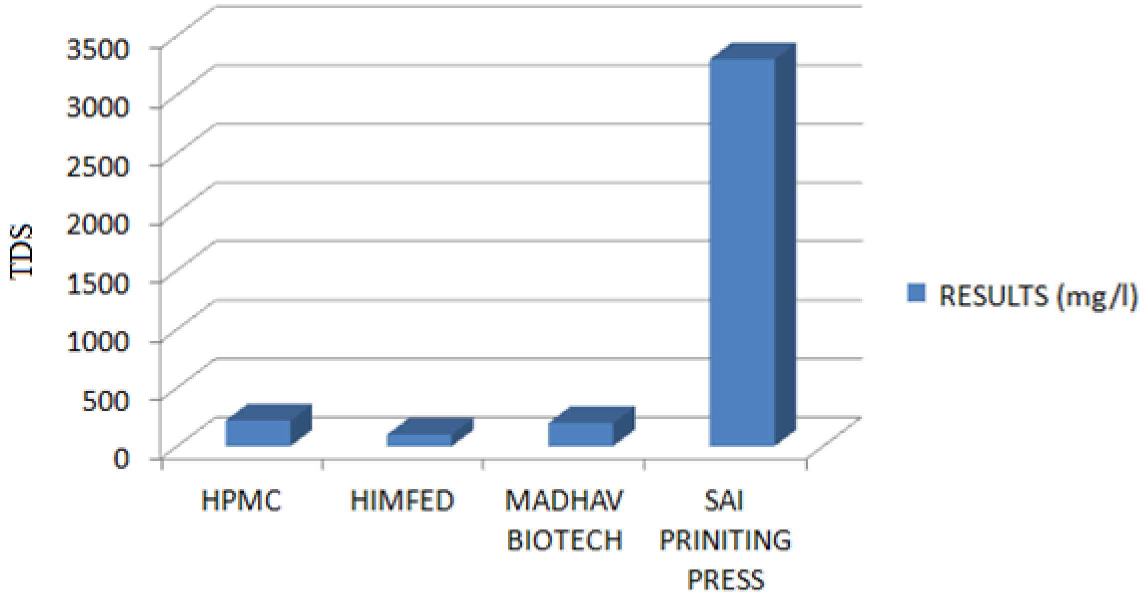

3500
3000
2500
2000
1500
1000
500
0
TDS
RESULTS (mg/l)
HPMC
HIMFED
MADHAV BIOTECH
SAI PRINITING PRESS

Fig. 5.5

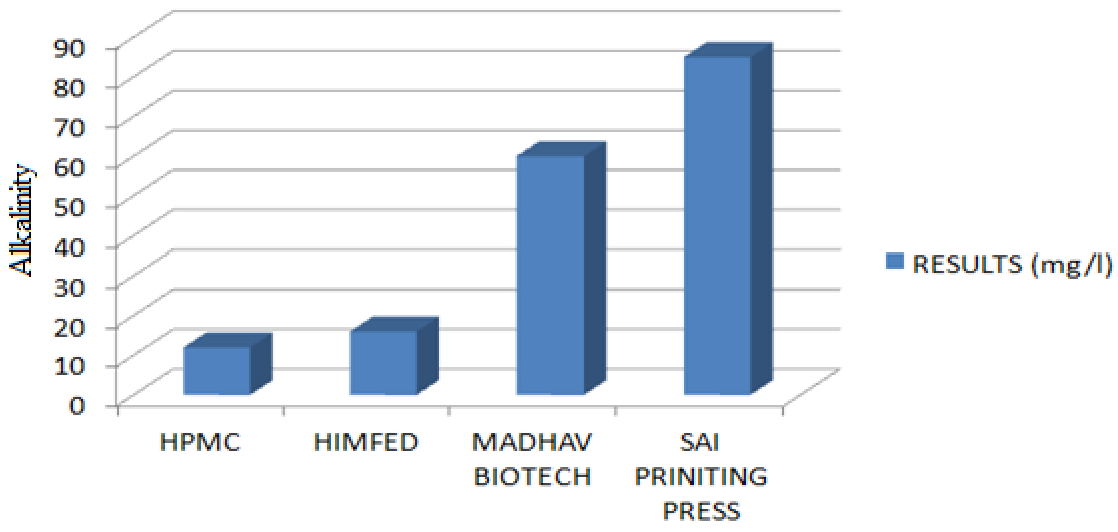

90
80
70
60
50
40
30
20
10
0
Alkalinity
RESULTS (mg/l)
HPMC
HIMFED
MADHAV BIOTECH
SAI PRINITING PRESS

Fig. 5.6

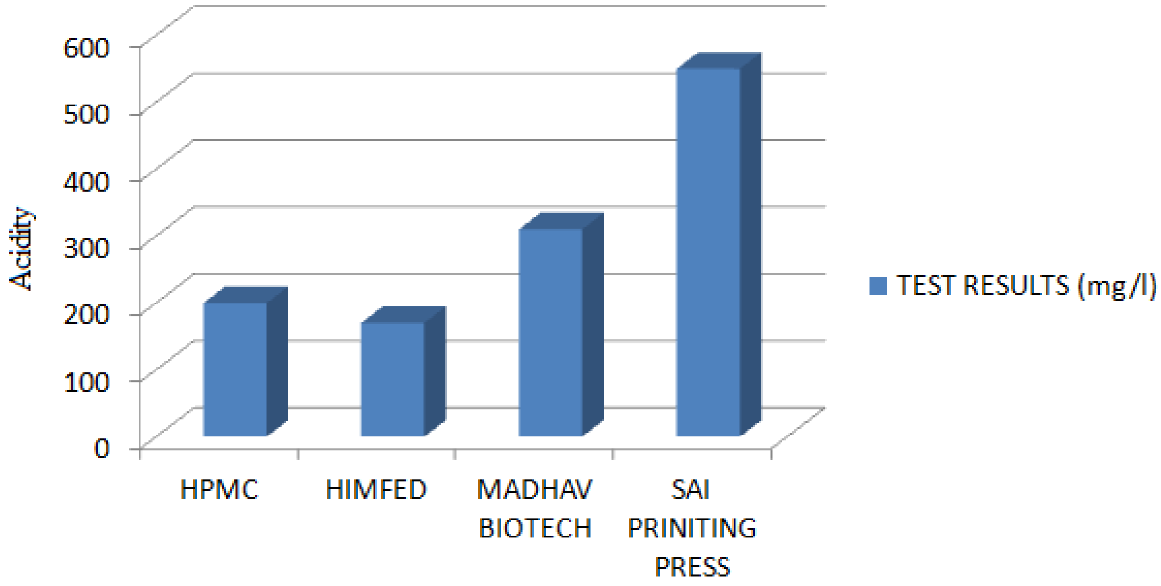

600
500
400
300
200
100
0
Acidity
HPMC
HIMFED
MADHAV BIOTECH
SAI PRINITING PRESS
TEST RESULTS (mg/l)

Fig. 5.7

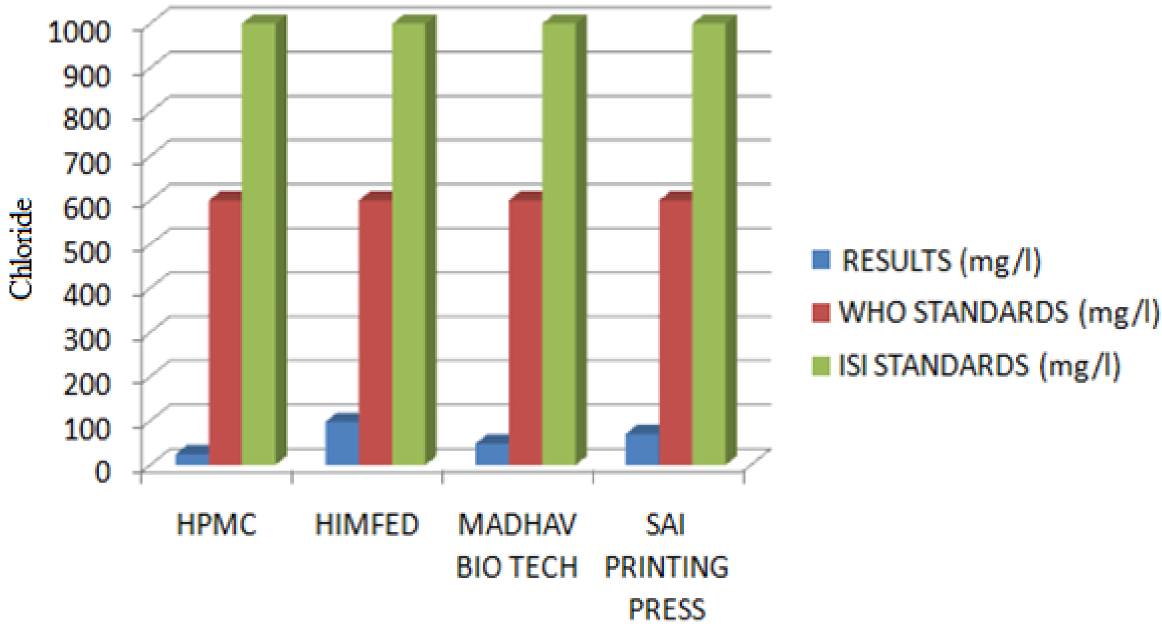

1000
900
800
700
600
500
400
300
200
100
0
Chloride
HPMC
HIMFED
MADHAV BIO TECH
SAI PRINTING PRESS
RESULTS (mg/l)
WHO STANDARDS (mg/l)
ISI STANDARDS (mg/l)

Fig. 5.8

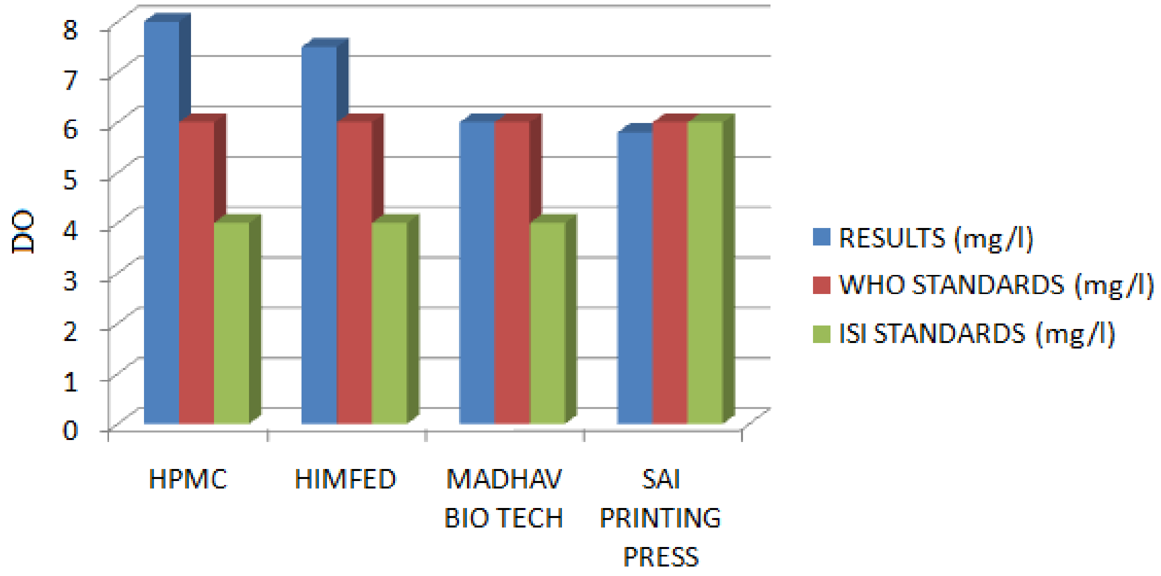


Fig. 5.9

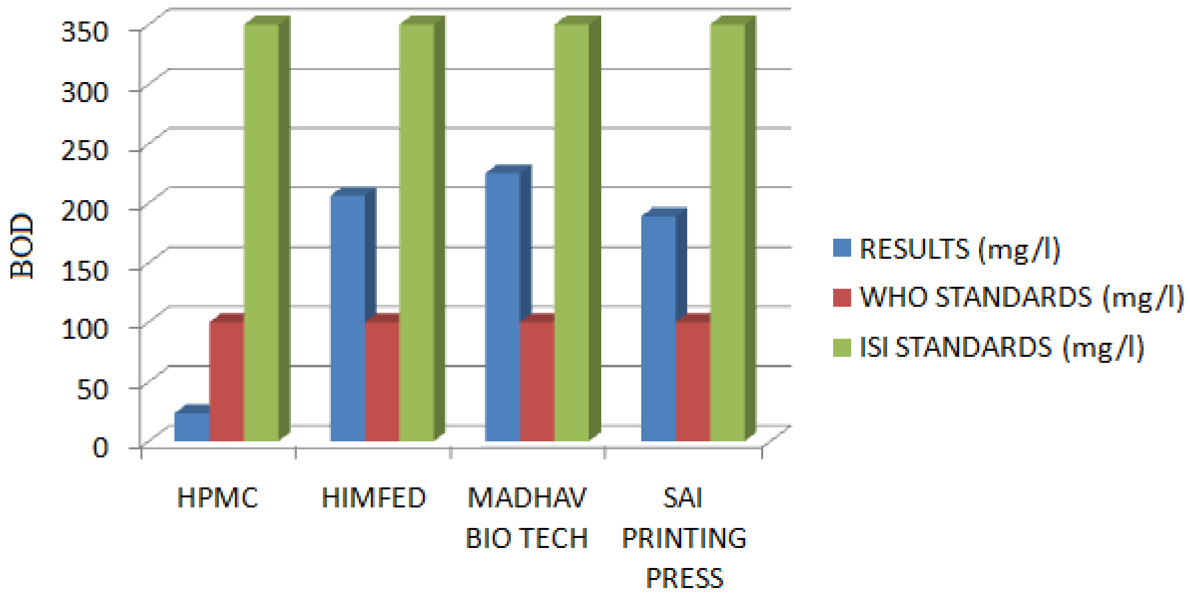


Fig. 5.10

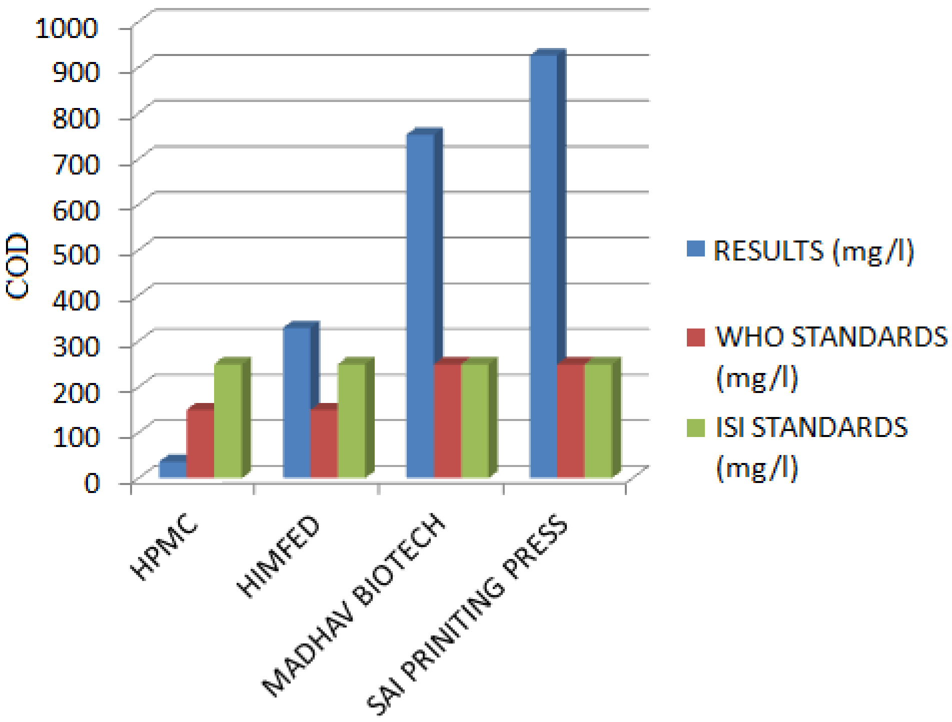

1000
900
800
700
600
500
400
300
200
100
0
COD
HPMC
HIMFED
MADHAV BIOTECH
SAI PRINITING PRESS
RESULTS (mg/l)
WHO STANDARDS (mg/l)
ISI STANDARDS (mg/l)

Fig. 5.11

CHAPTER 6

Water Quality Index

INTRODUCTION: (H.J. Vaux, "*Water quality (book review),"* environment, Vol. 43, No 3, 2001, page 39) A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. Political decision-makers, non-technical water managers, and the general public usually have neither the time nor the training to study and understand a traditional, technical review of water quality data. A number of indexes have been developed to summarize water quality data in an easily expressible and easily understood format. WQI basically acts as a mathematical tool to convert the bulk of water quality data into a single digit, cumulatively derived, numerical expression indicating the level of water quality. Role of WQI basically is:

1. WQI numerically summarizes the information from multiple water quality parameters into a single value.
2. The single value can be used to compare data from several sites.
3. It can be used to look at trends over time on a single site.
4. Quality of water can be determined with respect to given ranges of WQI as in table 6.1

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad

Table 6.1

PARAMETERS USED TO CALCULATE WATER QUALITY INDEX: A total of nine parameters are used to calculate the quality index of water. These parameters are listed below:

1. Temperature
2. pH
3. Dissolved Oxygen
4. Turbidity
5. ,Faecal Coliform,
6. Biochemical Oxygen,
7. Total Phosphates,
8. Nitrates
9. Total Suspended Solids

NOTE: The variables faecal coliform and total phosphates and nitrates are omitted for calculation of water quality index because:

1. Faecal coliform bacteria are present in sewage raw water and our samples are not sewage water.
2. Total phosphates and nitrates are mostly abundant in effluent from fertilizers manufacturing industries. Since our samples are not from these industries so these have been ignored for calculation of WQI.

PARTS OF WATER QUALITY INDEX:

1. Q-Value - indication of water quality relative to 100 of one parameter
2. Weighting Factor - sets the relative importance of the parameter to overall water quality

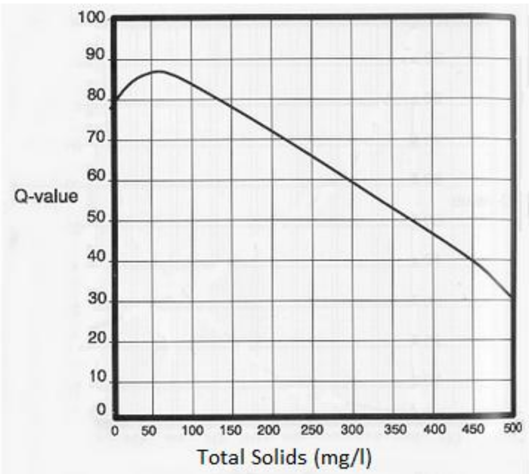
CALCULATING THE WQI:

1. After completing the five tests, the results are recorded and transferred to a weighting curve chart where a numerical value (Q-value) is obtained.
2. For each test, the Q-value is then multiplied by a “weighting factor.”
3. The nine resulting values are then added to arrive at an overall water quality index (WQI).

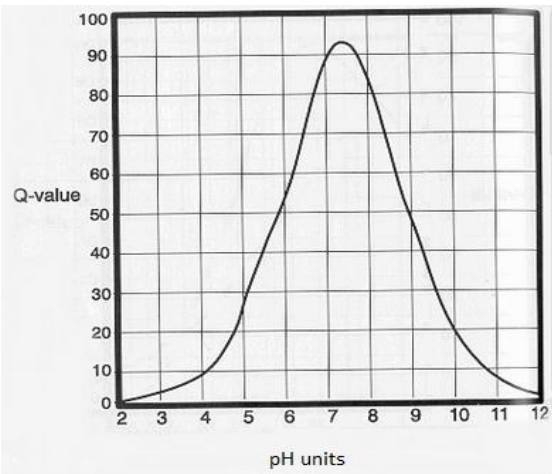
ASSIGNING THE Q VALUE:

1. Locate the chart for the appropriate test parameter.
2. Locate and mark the test result on the bottom, or horizontal axis, of the chart.
3. Beginning at the mark, draw a vertical line up until it intersects the curve on the chart.
4. From the point where the line intersected with the curve, draw a horizontal line to the left to reach the vertical axis of the chart.
5. Record the value where this horizontal line intersects the vertical axis of the chart on the form. This would be the Q-value for the test.
6. Repeat each of these steps to find the Q-value for each of the remaining tests results.
7. Make sure to record the correct Q-value in the appropriate column next to each test parameter on the WQI Worksheet before proceeding to the next step.

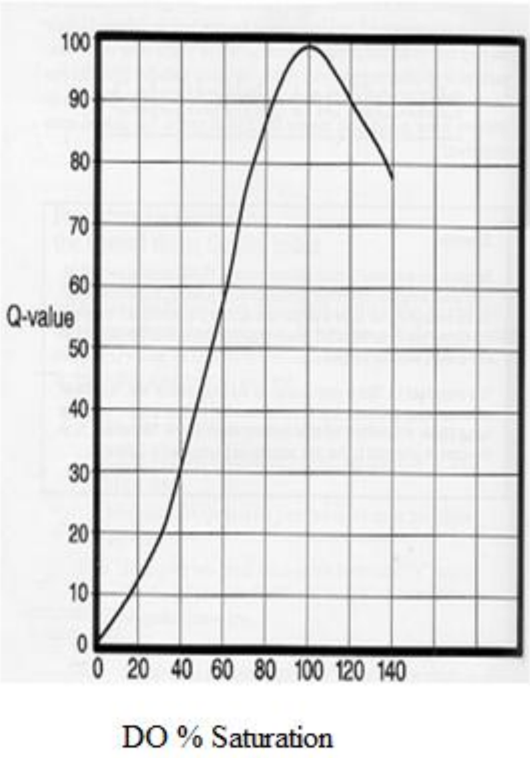
FIGURES USED FOR CALCULATION OF Q -VALUES: *(Water Research Center Retrieved March 10, 2015 from http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters)*



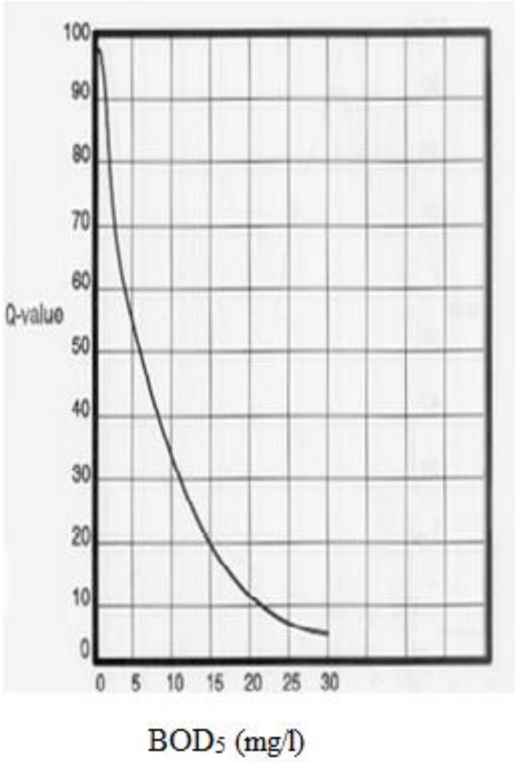
a) Q-value vs. TS



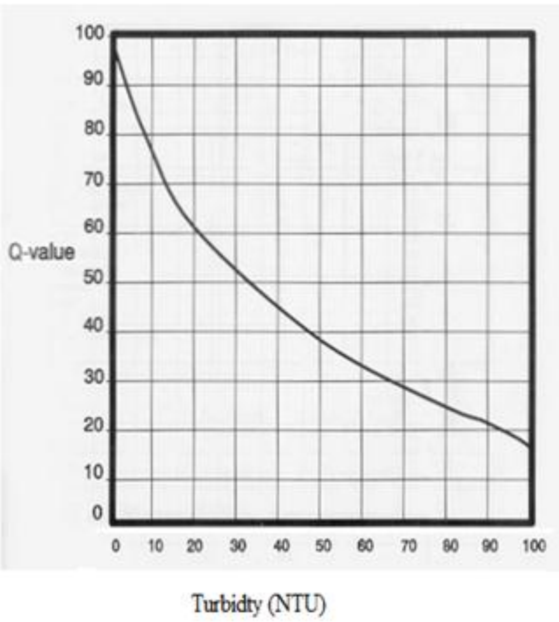
b) Q-value vs. pH



c) Q-value vs. DO% Saturation



d) Q-value vs. BOD_5



e) Q-value vs. Turbidity

Factor	Weight
Dissolved oxygen	0.17
Fecal coliform	0.16
pH	0.11
BOD	0.11
Total phosphate	0.1
Nitrates	0.1
Turbidity	0.08
Total solids	0.07

f) Water Quality index Factors and Weights

Fig. 6.1

SAMPLE CALCULATION FOR CALCULATING WQI:

WQI= (93*0.11+67*0.07+93*0.08+8*0.11+99*0.17)/0.54=74

Results have been summarized in table 6.2 Similar calculation have been carried for other industries as show in table 6.3 to table 6.5

WATER QUALITY INDEX OF TESTED SAMPLES:

HPMC

Parameter	Tested Value	Quality Rating Scale	Weighting Factor	Calculation
pH	7.5	93	0.11	10.23
Total Solids(mg/l)	240	67	0.07	4.69
Turbidity(NTU)	2.0	93	0.08	7.44
BOD(mg/l)	23.5	8.0	0.11	0.88
DO (% sat)	101	99	0.17	16.83
Totals			0.54	40.07/0.54=74

Table 6.2

HIMFED

Parameter	Tested Value	Quality Rating Scale	Weighting Factor	Calculation
pH	7.5	93	0.11	10.23
Total Solids(mg/l)	220	70	0.07	4.90
Turbidity(NTU)	9	78	0.08	6.24
BOD(mg/l)	206	2	0.11	0.22
DO(% sat)	94	98	0.17	16.66
Totals			0.54	38.25/0.54= **71**

Table 6.3

MADHAV BIOTECH

Parameter	Tested Value	Quality Rating Scale	Weighting Factor	Calculation
pH	7.5	93	0.11	10.23
Total Solids(mg/l)	700	20	0.07	1.4
Turbidity(NTU)	84	24	0.08	1.92
BOD(mg/l)	225	2	0.11	0.22
DO(% sat)	75	81	0.17	13.77
Totals			0.54	27.14/0.54= **49**

Table 6.4

SAI PRINTING PRESS

Parameter	Tested Value	Quality Rating Scale	Weighting Factor	Calculation
pH	8.5	66	0.11	7.26
Total Solids(mg/l)	5200	20	0.07	1.4
Turbidity(NTU)	700	5	0.08	0.4
BOD(mg/l)	189	2	0.11	0.22
DO(% sat)	72.6	78	0.17	13.26
Totals			0.54	22.54/0.54=**42**

Table 6.5

DISCUSSION: From the Q-value graphs it can be seen that the closer the tested value to the standard value more is the Q-value and their weightages are given according to the importance of parameters which have most effect on the quality of water. Also from the graphs it can be seen that after the particular value of tested value the Q-value remains constant. The WQI of two industries i.e. HPMC and HIMFED are 74 and 71 respectively which lie in good range of BIS standards. This illustrates that samples of these two industries are relatively clear. The WQI of Madhav BioTech and Sai printing press are 49 and 42 respectively which lie in the bad range of BIS standards. However these results do not provide the details about overall parameters and the treatment to be given cannot be concluded from these values. It only provides the basic idea about the quality of water.

CHAPTER 7

Principal Component Analysis (PCA)

INTODUCTION: (Principal Component Analysis," *International Journal of Geosciences*, Vol. 4 No. 2, 2013, pp. 444-453).It is a dimension-reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. Principal component analysis is performed on a square symmetric matrix. (We have chosen correlation matrix because the variances of individual variants differ much, and units of measurement of the individual variants differ.)

Objectives of Principal Component Analysis:

1. PCA reduces attribute space from a larger number of variables to a smaller number of factors and as such is a "non-dependent" procedure (that is, it does not assume a dependent variable is specified).

2. PCA is a dimensionality reduction or data compression method. The goal is dimension reduction and there is no guarantee that the dimensions are interpretable.

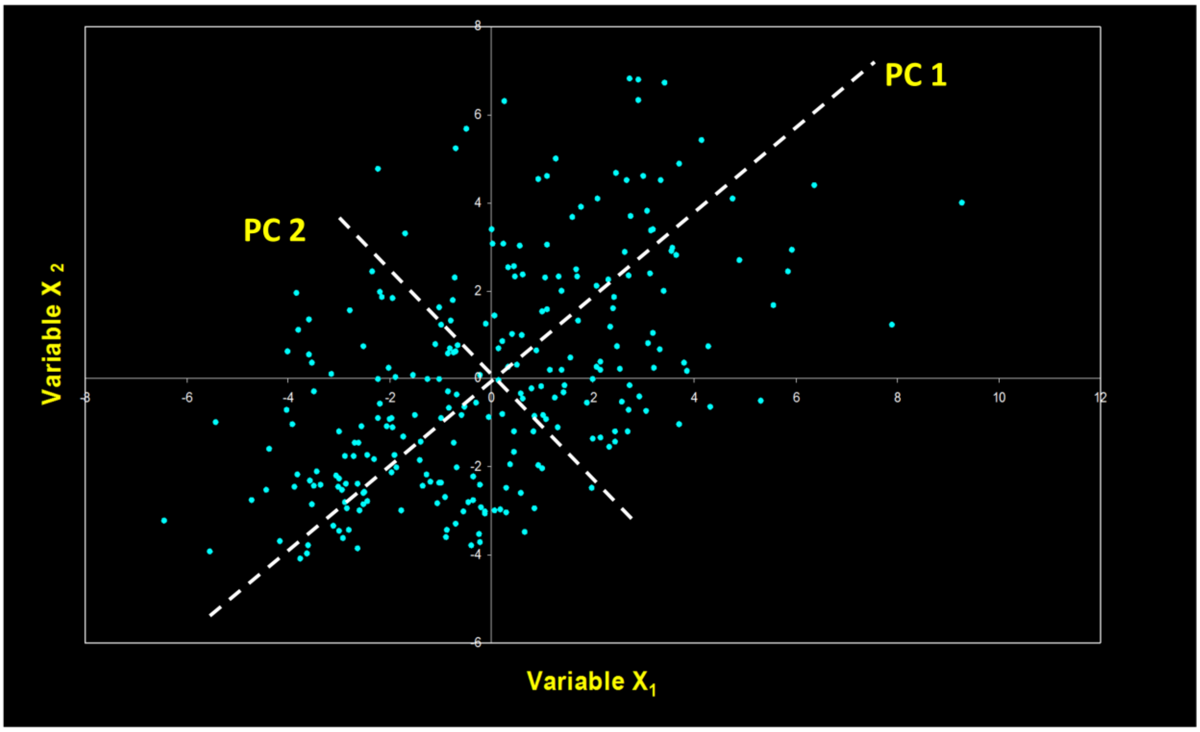
3. To select a subset of variables from a larger set based on which original variables have the highest correlations with the principal component.

Components of PCA: (www.cse.psu.edu/~rtc12/pcaLecture)

Eigenvectors: It reflects both common and unique variance of the variables and may be seen as a variance-focused approach seeking to reproduce both the total variable variance with all components and to reproduce the correlations. An eigenvector gives direction, in the figure given below the eigenvector shows the direction of the line which is approximately 45 degrees to vertical and horizontal axis. An eigenvector gives direction, in the figure given below the eigenvector shows the direction of the line which is approximately 45 degrees to vertical and horizontal axis which is of principle component.

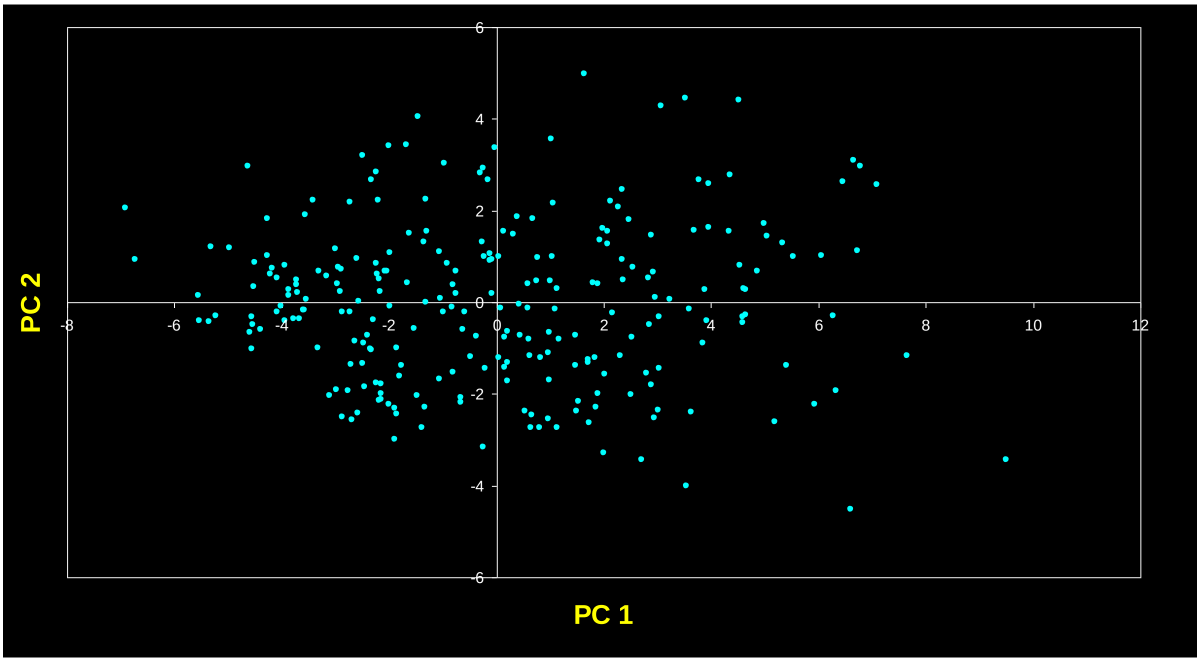
Eigen values: It is called characteristic roots of matrix. The eigen value for a given factor measures the variance in all the variables which is accounted for by that factor. The ratio of eigen values is the ratio of explanatory importance of the factors with respect to the variables. If a factor has a low eigen value, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. Eigen values measure the amount of variation in the total sample accounted for by each factor. In the figure given the eigen value is a number telling us how spread out the data is on the line. The eigenvector with the highest eigen value is therefore the principal component.

PC scores: Also called component scores in PCA, these scores are the scores of each case (row) on each factor (column). To compute the factor score for a given case for a given factor, one takes the case's standardized score on each variable, multiplies by the corresponding factor loading of the variable for the given factor, and sums these products.



a) Plot between Variable X_1 & Variable X_2

(https://www.google.com/url/component analysis 2)



b) Plot between PC1 & PC2

Fig 7.1

(https://www.google.com/url/component analysis%2)

METHODOLOGY OF PCA:

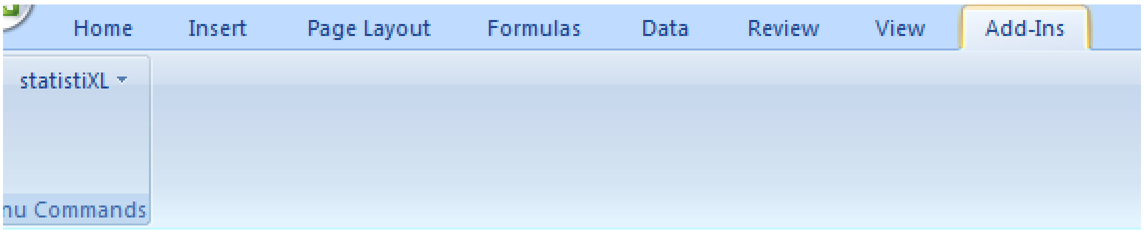


Fig. 7.2 a) Step 1

1. Go to excel, click on Add-Ins.
2. Go to statistiXL.
3. Go to Principal Components.

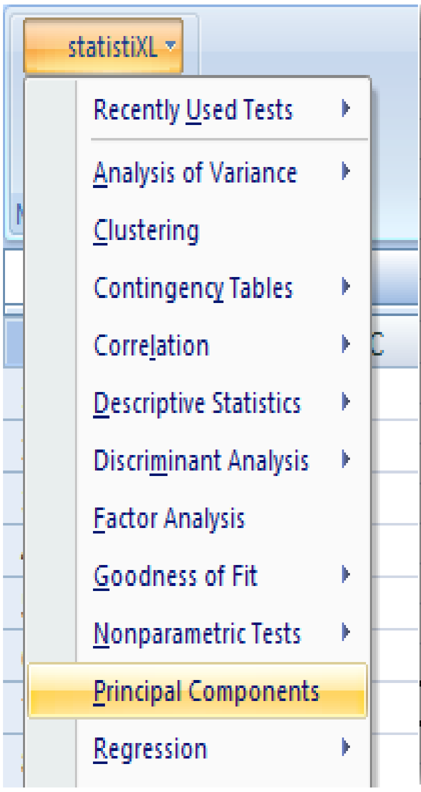


Fig.7.2 b) Step 2

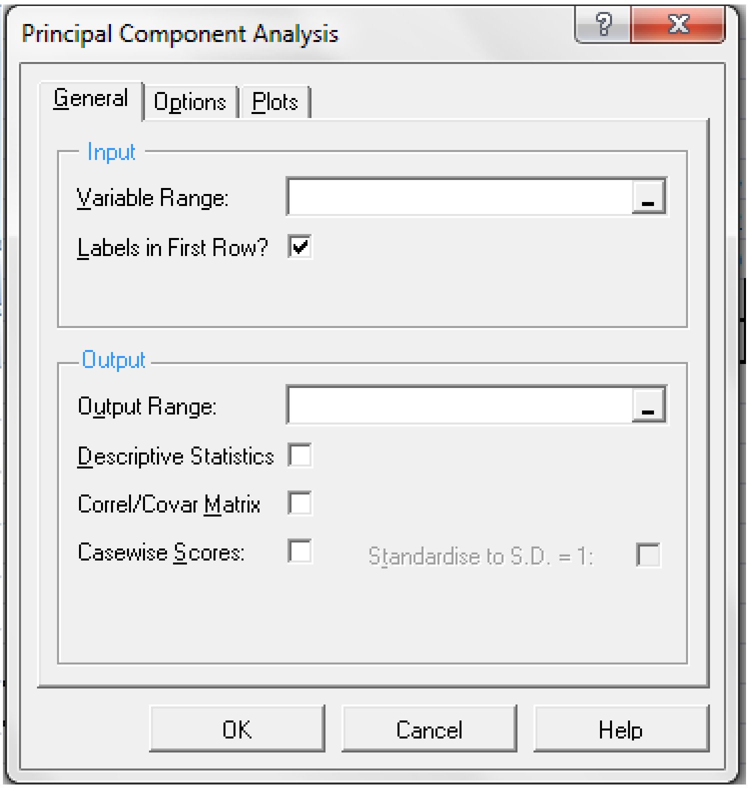
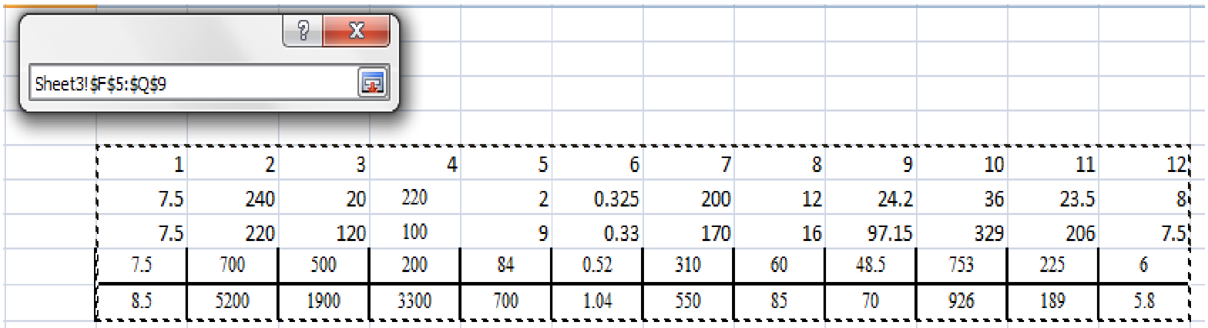


Fig.7.2 c) Step 3

4. Select variable range.



1	2	3	4	5	6	7	8	9	10	11	12
7.5	240	20	220	2	0.325	200	12	24.2	36	23.5	8
7.5	220	120	100	9	0.33	170	16	97.15	329	206	7.5
7.5	700	500	200	84	0.52	310	60	48.5	753	225	6
8.5	5200	1900	3300	700	1.04	550	85	70	926	189	5.8

Fig.7.2 d) Step 4

5. Click on options, select correlation matrix, and select number of components equal to three.

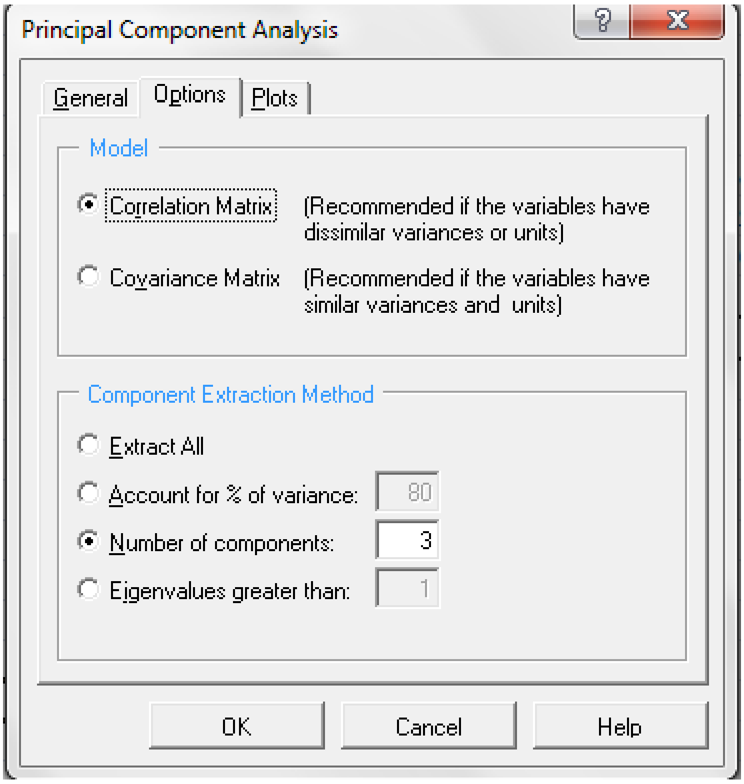


Fig.7.2 e) Step 5

6. Go to Plots and select Scree Plot and select number components equal to three.
7. Go to General , select output range, select casewise score and click OK

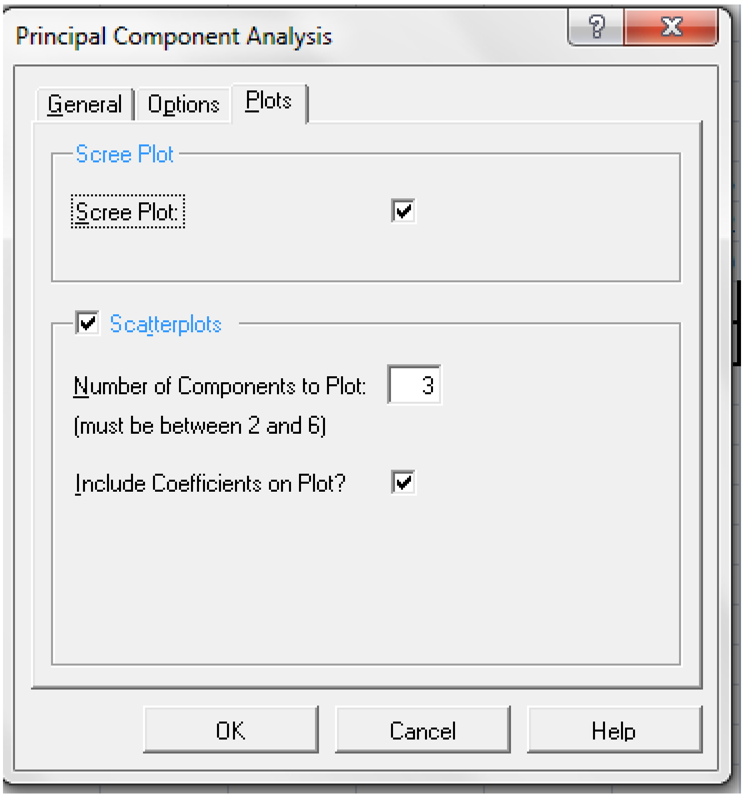


Fig.7.2 f) Step 6

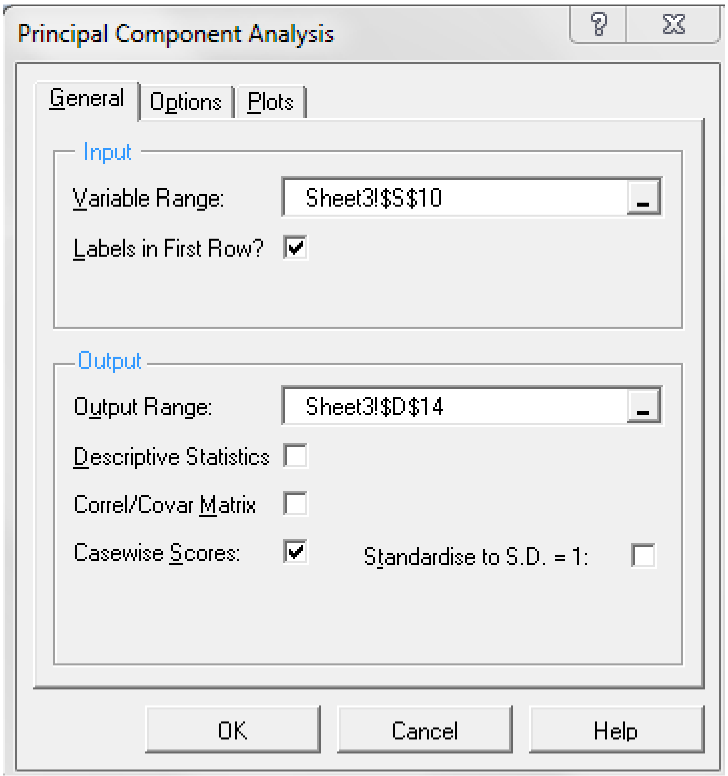


Fig.7.2 g) Step 7

RESULTS:

PCA ON THE BASIS OF PHYSIO CHEMICAL PARAMETERS:

PARAMETERS/ FACTORIES	1	2	3	4	5	6	7	8	9	10	11	12
HPMC	7.5	240	20	220	2	0.325	200	12	24.2	36	23.5	8
HIMFED	7.5	220	120	100	9	0.33	170	16	97.15	329	206	7.5
MADHAV BIOTECH	7.5	700	500	200	84	0.52	310	60	48.5	753	225	6
SAI PRINTING PRESS	8.5	5200	1900	3300	700	1.04	550	85	70	926	189	5.8

In graph the numerals from 1 to 12 designate:

1. pH
2. Total Solids
3. Suspended Solids
4. Dissolved Solids
5. Turbidity
6. Conductivity
7. Alkalinity
8. Acidity
9. Chloride Content
10. COD
11. BOD
12. DO

Explained Variance (Eigenvalues)

Value	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10	PC 11	PC 12
Eigenvalue	9.270	1.800	0.930	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% of Var.	77.249	15.002	7.749	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cum. %	77.249	92.251	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

Component Loadings

(correlations between initial variables and principal components)

Variable	PC 1	PC 2	PC 3
1	0.936	-0.253	-0.244
2	0.962	-0.217	-0.163
3	0.992	-0.107	-0.061
4	0.936	-0.275	-0.218
5	0.968	-0.198	-0.153
6	0.992	-0.126	-0.009
7	0.983	-0.156	0.094
8	0.947	0.097	0.305
9	0.248	0.705	-0.664
10	0.896	0.363	0.255
11	0.466	0.884	0.043
12	-0.859	-0.321	-0.398

Table 7.1

Component Score Coefficients (Eigenvectors)

Variable	PC 1	PC 2	PC 3
1	0.308	-0.189	-0.253
2	0.316	-0.161	-0.169
3	0.326	-0.080	-0.064
4	0.308	-0.205	-0.226
5	0.318	-0.148	-0.159
6	0.326	-0.094	-0.010
7	0.323	-0.117	0.098
8	0.311	0.073	0.317
9	0.081	0.526	-0.689
10	0.294	0.271	0.265
11	0.153	0.659	0.044
12	-0.282	-0.239	-0.413

Casewise PCA Scores

Case	PCA 1	PCA 2	PCA 3
1	-2.560	-1.661	0.102
2	-1.723	1.208	-1.020
3	0.007	0.962	1.271
4	4.276	-0.509	-0.352

Table 7.2

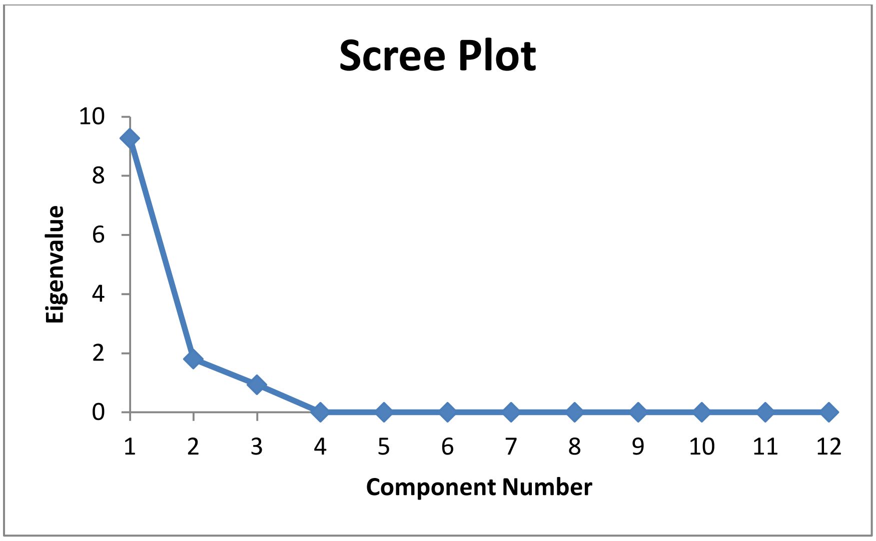

Scree Plot
Eigenvalue
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
Component Number

Fig. 7.3

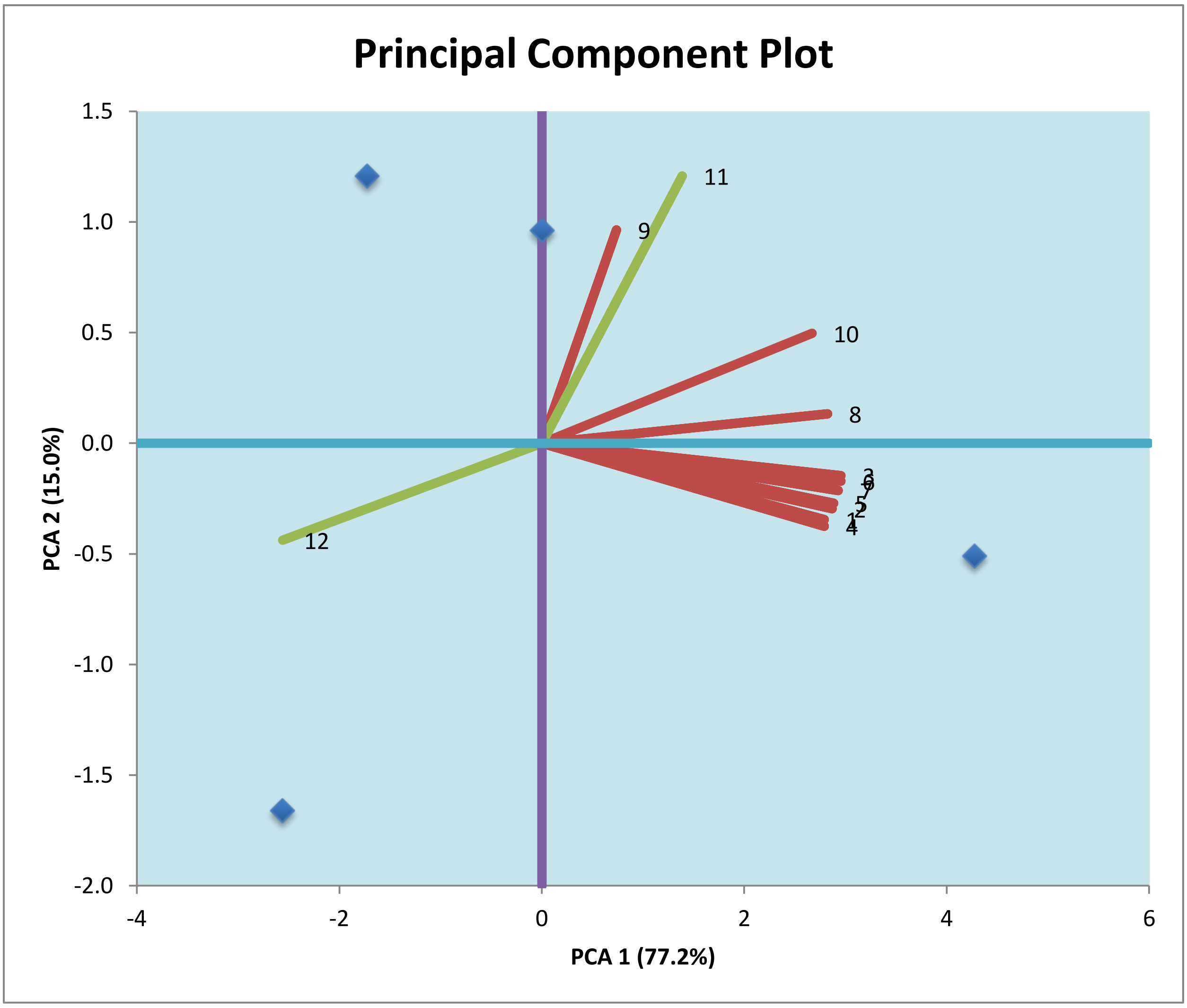

Principal Component Plot
PCA 2 (15.0%)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-4
-2
0
2
4
6
PCA 1 (77.2%)
11
9
10
8
12

Fig. 7.4

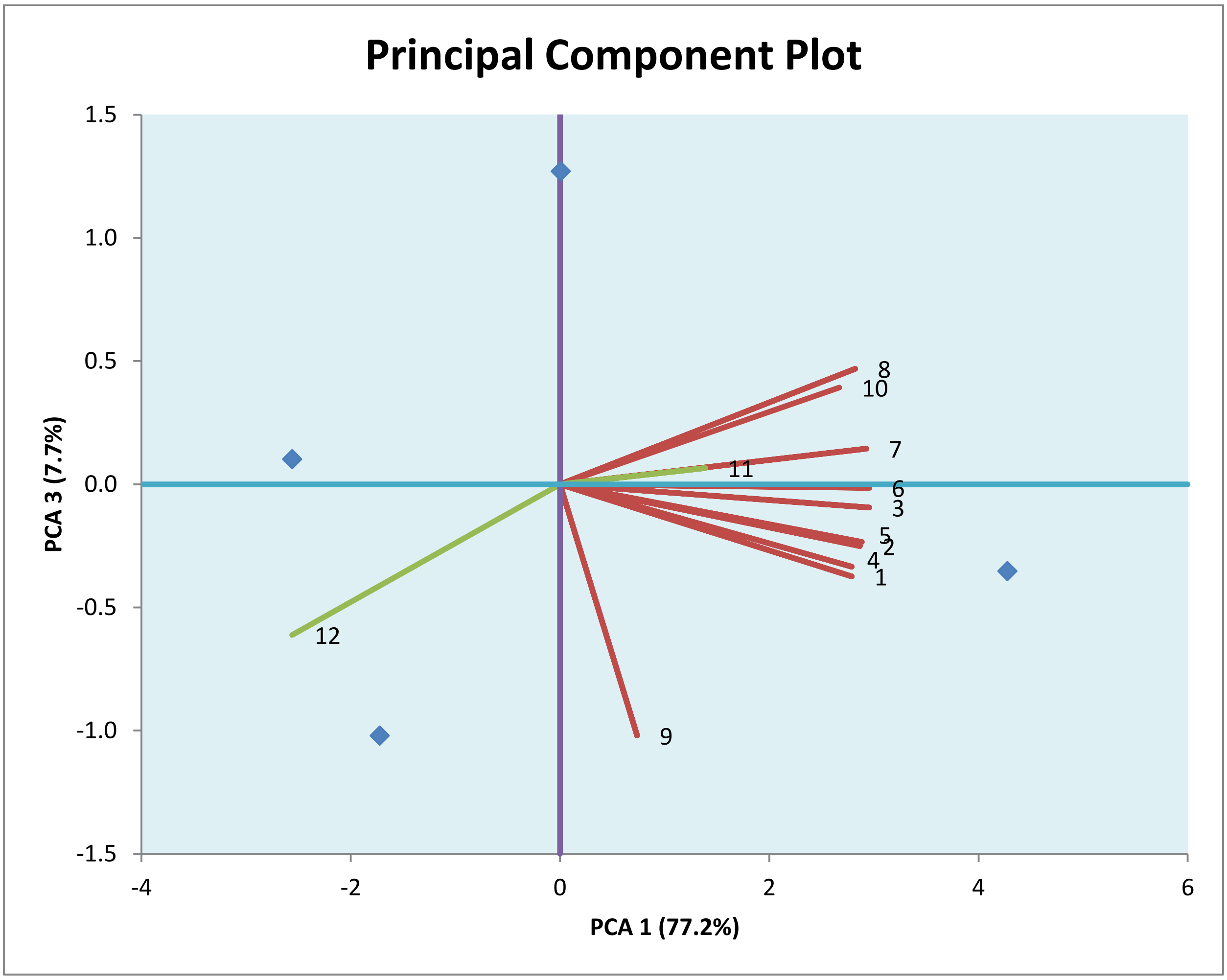

Principal Component Plot
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
PCA 3 (7.7%)
-4
-2
0
2
4
6
PCA 1 (77.2%)
8
10
7
11
6
3
5
2
4
1
12
9

Fig 7.5

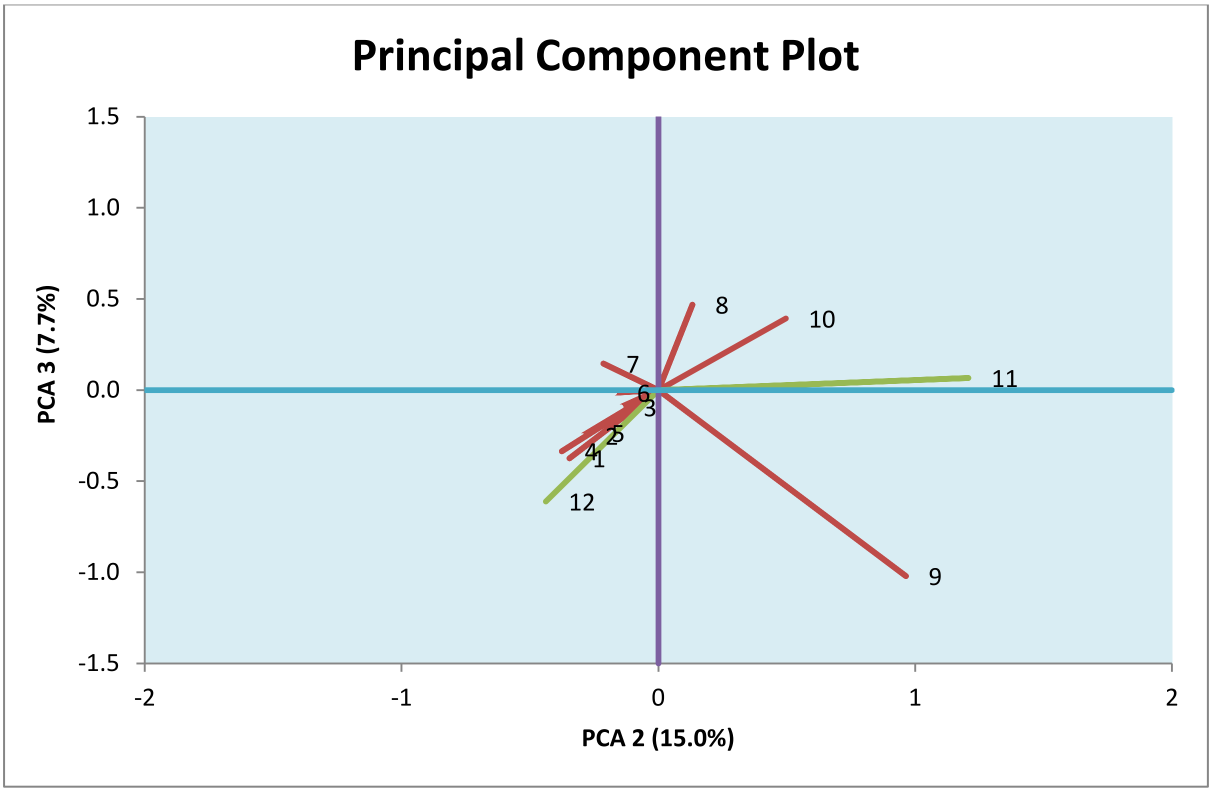

Principal Component Plot
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
PCA 3 (7.7%)
-2
-1
0
1
2
PCA 2 (15.0%)
8
10
7
11
6
3
5
2
4
1
12
9

Fig 7.6

PCA ON THE BASIS OF WATER QUALITY INDEX DATA:

PARAMETERS/FACTORIES	pH	Total Solids	Turbidity	BOD	DO
HPMC	10.23	4.69	7.44	0.88	16.83
HIMFED	10.23	4.9	6.24	0.22	16.66
MADHAV BIOTECH	10.23	1.4	1.92	0.22	13.77
SAI PRINTING PRESS	7.26	1.4	0.4	0.22	13.26

PRINCIPAL COMPONENT ANALYSIS TABLE:

Explained Variance (Eigenvalues)

Value	PC 1	PC 2	PC 3	PC 4	PC 5
Eigenvalue	3.895	0.670	0.435	0.000	0.000
% of Var.	77.903	13.390	8.707	0.000	0.000
Cum. %	77.903	91.293	100.000	100.000	100.000

Component Loadings

(correlations between initial variables and principal components)

Variable	PC 1	PC 2	PC 3
pH	0.740	-0.515	0.433
Total Solids	0.947	-0.029	-0.320
Turbidity	0.998	0.000	-0.062
BOD	0.701	0.634	0.326
DO	0.982	-0.037	-0.188

Component Score Coefficients (Eigenvectors)

Variable	PC 1	PC 2	PC 3
pH	0.375	-0.630	0.656
Total Solids	0.480	-0.035	-0.485
Turbidity	0.506	0.000	-0.094
BOD	0.355	0.775	0.494
DO	0.497	-0.045	-0.284

Case wise PCA Scores			
Case	PCA 1	PCA 2	PCA 3
1	2.076	0.778	0.323
2	1.192	-0.771	-0.659
3	-1.077	-0.639	0.764
4	-2.190	0.632	-0.429

Table 7.3

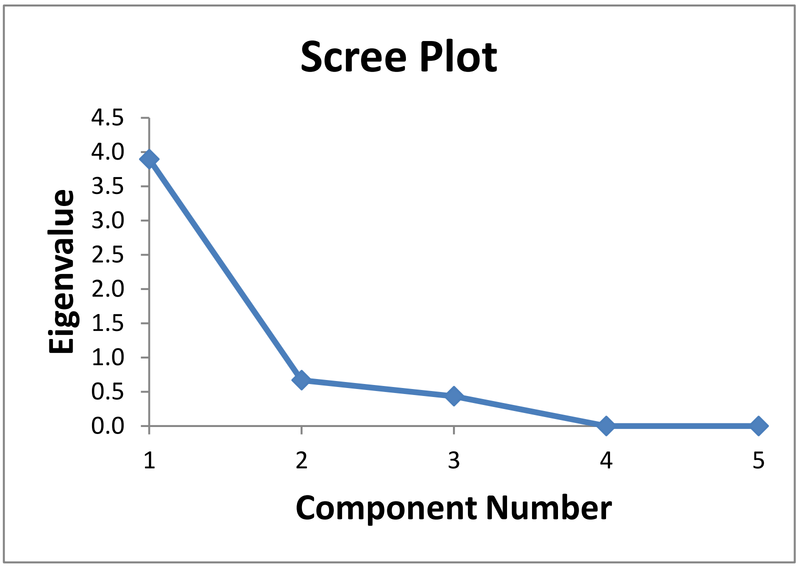


Fig 7.7

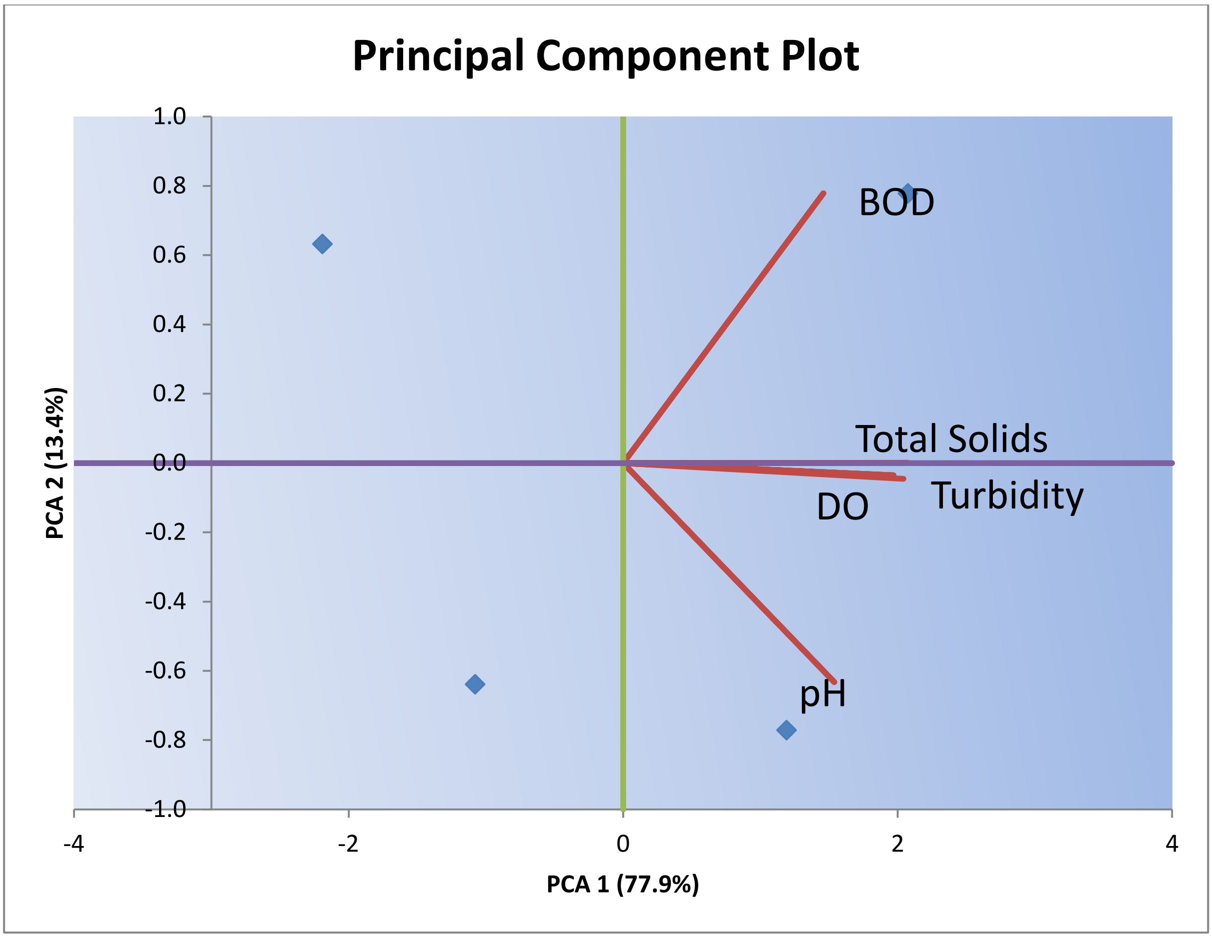

Principal Component Plot
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-4
-2
0
2
4
PCA 2 (13.4%)
PCA 1 (77.9%)
BOD
Total Solids
Turbidity
DO
pH

Fig 7.8

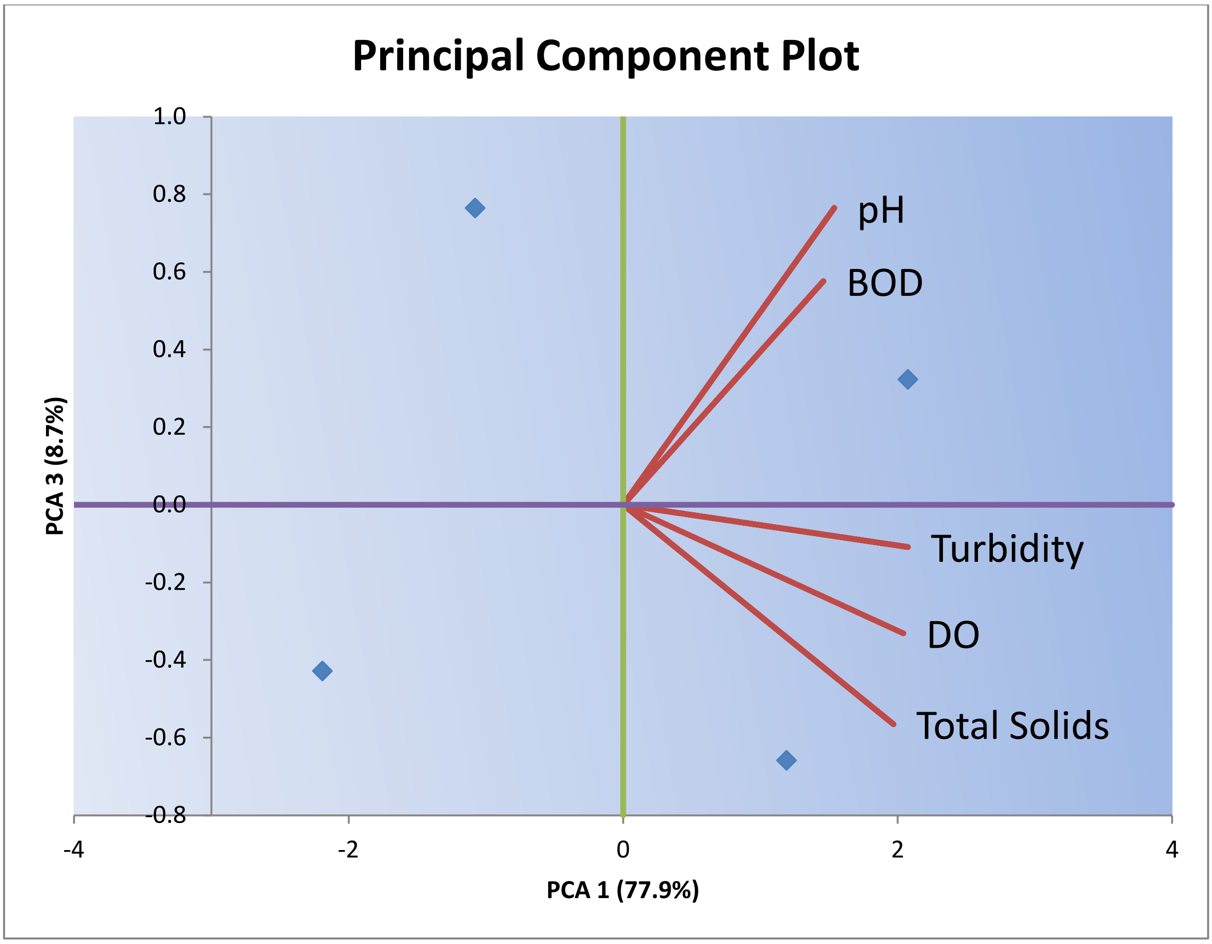


Fig 7.9

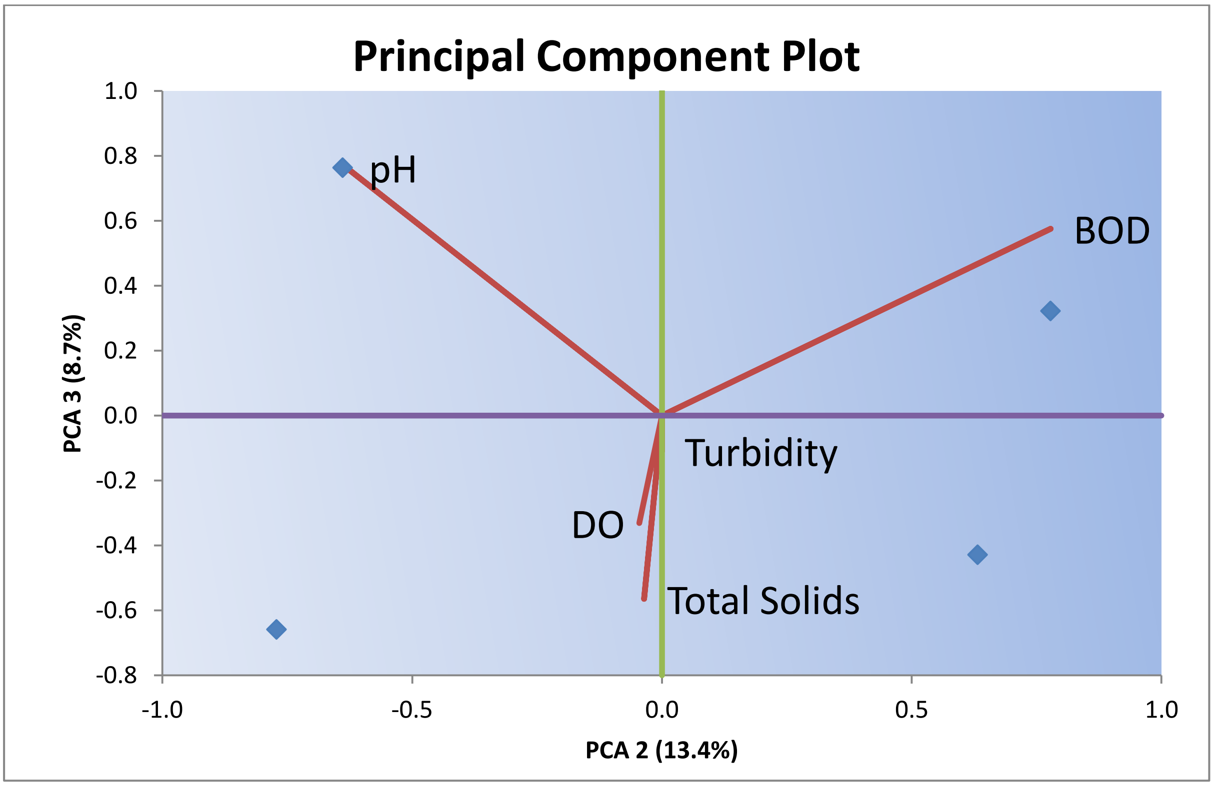


Fig 7.10

DISCUSSION: PCA analysis is carried out to convert the large set of data into smaller set that still contains most of the information of the large set. PCA analysis is also used to find out any missing data and also establish the relation between the variables. The plot which accounts for highest variability in the data is the most significant and is used to study the relation. The closer the angle between the variables more is the positive relation between the two. If the angle between the variables is 90º then the variables are independent. If the relation between the variables is 180º then there is negative relation. The PCA analysis is carried out using both the physio-chemical variables as well as WQI. From the plot 1(Fig 7.4) of physio-chemical variables it can be seen the relation between dissolved solids and conductivity is positive. This shows that they both are dependent on each other. Also the relation between BOD and DO is negative relation.

CHAPTER 5

DISCUSSION

On comparison with different parameters of different industries we can infer from above graphs the reasons behind high or low value of effluent from industries.

The COD and BOD values both are a measure of the relative oxygen –depletion of waste water. Both have been adopted as a measure of pollution effect. In present investigation COD of Madhav Biotech and Sai Printing press is very high due to give large value of COD as large number of non biodegradable and inorganic solvents used in these industries like dyestuff and solvent residues, wiping material containing dyes , inorganic compound used in pharmaceutical industries .But BOD /COD ratio of these industries (Madhav Biotech and Sai Printing Press) are comparatively less as compared to HIMFED and HPMC because their source of production is from fruits and on processing of which results in organic matter which increases the BOD and their COD values are lower due to some amount of detergents are used for cleaning which are inorganic in nature. COD and BOD of Madhav Biotech and Sai Printing are not within range. Conductivity of Sai Printing Press is high due to high amount of TDS present in the sample which consists of dye stuff, wiping materials. Madhav Biotech and Sai Printing have higher alkalinity relative to the remaining ones due to presence and bi-carbonates used in these industries. Chlorides limits of all the industries are with in prescribed limits. The WQI index of two industries i.e. HPMC and HIMFED are 74 and 71 which lie in good range of BIS standards. This illustrates that the samples of these two industries are relatively clear and require minimal treatment. The WQI of Madhav biotech and Sai printing press are 49 and 42 respectively which lies in bad range of BIS standards and need proper treatment before they are disposed off. PCA analysis helps us in establishing relationships between parameters. The plot 1 is most significant as the variation is more.The lesser the angle between the parameters more are the quantities related. And if angle between the parameters is close to 90º it signifies that the parameters have no relation between them. As the angle between DO and BOD is approximately equal to 180º it shows that there is negative relation between them. Also pH and chloride content have angle of 90º which signifies that there is no relation between the parameters. Similar results are deduced from the WQI plots as well.

CHAPTER 6

CONCLUSION

It can be seen from the above results that HPMC and HIMFED samples have almost all the values within the permissible limits. Therefore they can be discharged in inland surface with minimal treatment. The test results also show that the other two samples have parameters which are not within the permissible limits and thus efficient treatment is required for the safe disposal of the effluents. They cannot be directly disposed off in inland surface waters. These results are again verified by the water quality index analysis which shows that the results of samples of HIMFED and HPMC fall in good category. The water samples of Sai printing and Madhav Biotech fall in bad category and needs to be provided with proper treatment before they are disposed off. The relations are established with the help of PCA analysis which can also be used to find out any missing data if samples from any stations were misplaced.

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