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Performance, Evaluation and Suggestion Study of ETP of Galvansing Unit- A Case Study on KEC Industry

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I. INTRODUCTION

A. About KEC Industries

- KEC International Limited In Panagar, Jabalpur

KEC International Limited in Panagar, Jabalpur, a leading provider of comprehensive contracting and building services, specializes in delivering high- quality solutions that cater to Builders projects. The company's experienced professionals are dedicated to ensuring that every project, regardless of size, is executed with precision and excellence. At KEC International Limited in Panagar, Jabalpur, they are committed to transforming their clients' visions into reality by offering reliable and efficient services that meet their specific needs.

- Mission

KEC International Limited in Panagar, Jabalpur's mission is to exceed their clients' expectations by offering top-tier services.The company is driven by a passion for excellence and a commitment to delivering projects that stand the test of time. Their focus is on providing solutions, maintaining the highest standards of quality, and ensuring complete customer satisfaction. By leveraging their extensive experience, they aim to create spaces that are functional, aesthetically pleasing, and sustainable.

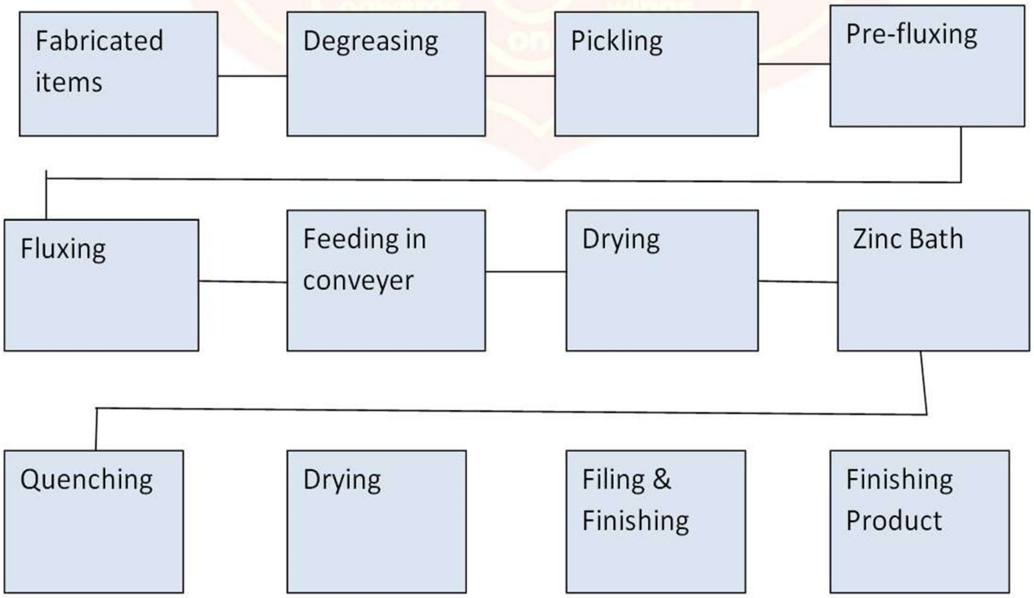
- Our Product – Transmission & Railway Electrification Galvanized Steel Structures
- New Products – Scaffolding & Formworks for Civil Business
- Additional Service – SAIL Yard (Stocking & Distribution)

TREATMENT & DISPOSAL FACILITIES

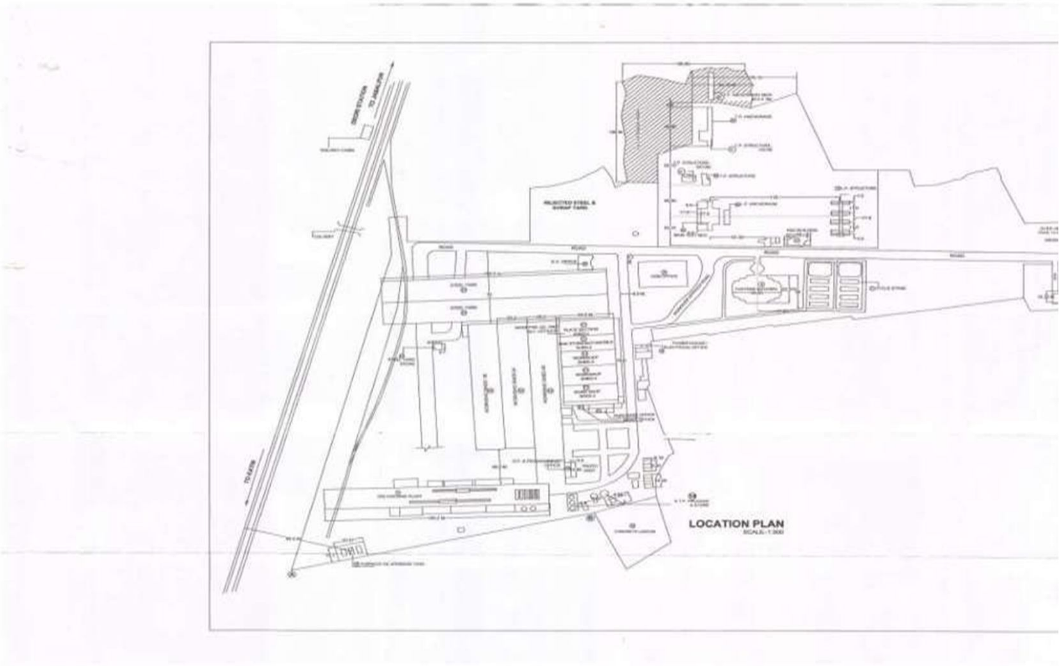
ETP PLANT

B. Galvansing Process

Galvansing is a process where by zinc is applied on a steel surface for corrosion protection. Zinc consumption in a continuous galvanizing line is one of the highest operating cost items in the facility and minimizing zinc wastage is a key economic objective for any operation.



C. Industrial Site Plan



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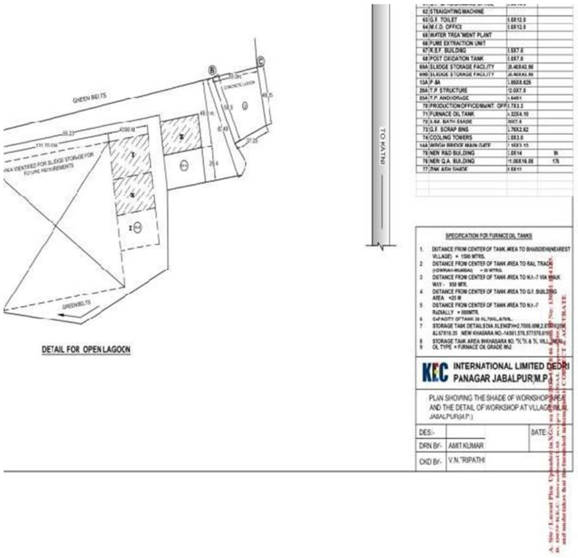
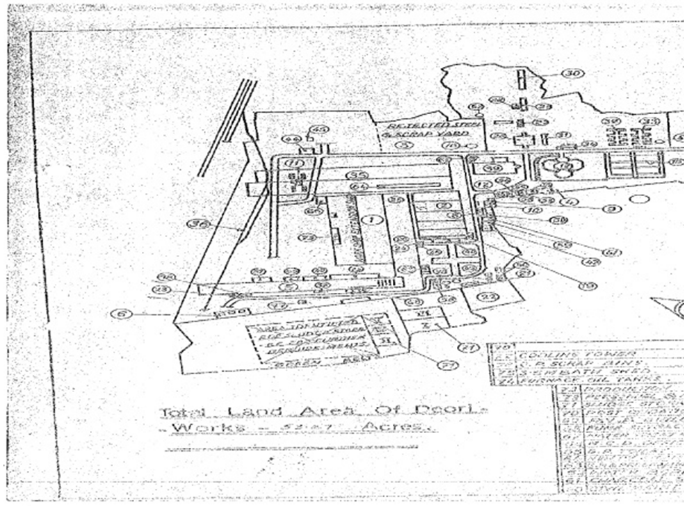
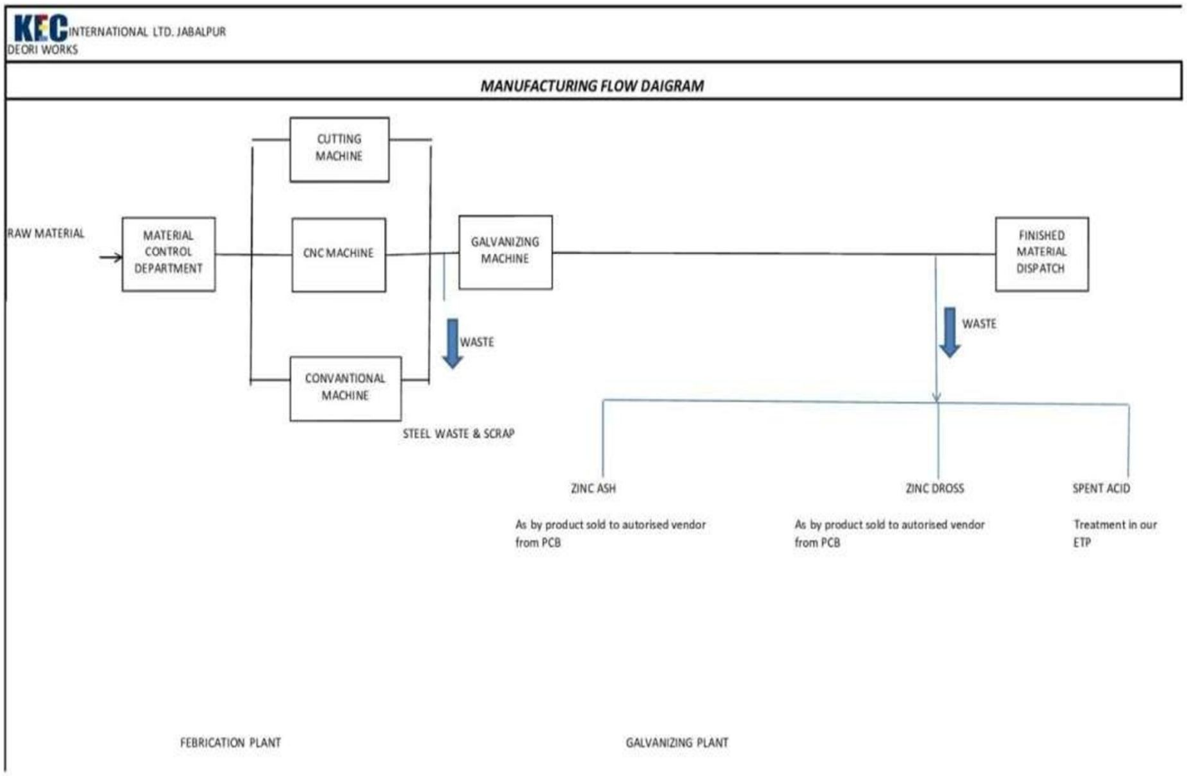




D. Sources of Wastage



1) Dross formation:
- Dross is a by product of the galvanizing process that forms by reactions between molten zinc and loose particles of iron in the galvanizing kettle.
- It contains 90%-95% of zinc.

2) Zinc ash:
- Zinc ash is a mixture crude and varying quantities on entrained metallic zinc.
- It contains 60%-70% of zinc.

3) Pickup
- Actual zinc pickup after galvanizing will rely on the average thickness of coating and section design.
- Excess average coating of zinc contribute to zinc wastage.

4) Human Error
- Ignorance and poor supervision of workers.

E. Process Effluent Treatment Plant (Dichromate Stream

They have got facility for treatment of dichromate solution for reduction of chromium from hexavalent to trivalent. This stream is not in use due to elimination of effluent generated from the process. Earlier, there was continuous overflow from the (dichromate) Quenching Tank, due to addition of fresh water for the purpose of cooling of solution.

As the quenching system is having abundant heat, it is being utilised for heating of Flux solution and Degreasing solution, by circulating hot quenching solution through Heat Exchangers.

F. F. Mode Of Storage Within Plant/ Method Of Disposal Of Hazardous Waste

1. Zinc Dross:

It is collected from the bottom of molten zinc from galvanizing kettle and allowed to solidify in small containers periodically. The solidified dross is in the form of Trapezoidal slab having weight around 25 – 30 Kgs. This remains in stable solid form at ambient temperature. This is stored in a enclosed storage in a stacked manner.

It is a by-product for us and is being sold to various vendors who are possessing authorization from the respective Pollution Control Boards. These vendors transport Zinc Dross through trucks.

2. Zinc Ash:

It is in powder form and is collected in polythene bags. These polythene bags are kept under shed. It is also a by-product and is being sold to various vendors who are possessing authorization from the respective Pollution Control Boards. These vendors transport Zinc Ash bags through trucks.

3. ETP Sludge :

It is in the form of cake, which is formed at the Drying Beds. The cake is formed on a uniform basis and is continuously collected in trolleys. The trolleys are shifted to Off- site Sludge Disposal Facility developed within plant premises. The trolleys are decanted and sludge is disposed off into the Disposal Facility.

The Off-site Sludge Disposal Facilities have been constructed as per the MOEF guidelines and as per the approved design..

4. Waste Pickled Acid :

We are using Hydrochloric acid (33% commercial grade) for surface treatment of our raw tower parts structure, and waste acid (5%) are being treated in our ETP. This will be continued till we find a suitable party, authorized by MOEF/ respective Pollution Control Board, who can use our SPENT ACID as a raw Material of there product

5. Spent oil :

Spent oil are being generated form various gear box, Generator etc. and major quantity of the same, we are using for out side lubrication of our G.P. conveyor chain.

II. LITERATURE SURVEY

A. Case Studies and Regional Approaches

Examining real-world examples and regional variations provides valuable insights into effective wastewater treatment practices. These cases highlight innovative solutions and showcase how different areas tackle unique challenges.

B. Success Stories in Wastewater Treatment

Several industries have made significant strides in treating wastewater. A notable example is a paper mill in Oregon that implemented a closed-loop system. This approach reduced water usage by 90% and eliminated all wastewater discharge.

Another success story comes from a textile factory in India. They installed a membrane bioreactor system, cutting water consumption by 60% and meeting strict effluent standards.

In Germany, a chemical plant adopted advanced oxidation processes. This method effectively removed persistent organic pollutants, improving effluent quality dramatically.

C. Bay of Plenty: A Case Study

The Bay of Plenty region in New Zealand offers a compelling case study in industrial wastewater management. Local authorities implemented a comprehensive monitoring program for industrial discharges.

Key features of the Bay of Plenty approach:

- Regular effluent sampling at all major industrial sites
- Real-time monitoring systems for high-risk facilities
- Collaborative partnerships between industries and regulators
- Incentives for businesses adopting best practices

This proactive strategy led to a 40% reduction in pollutant loads entering the bay over five years. It also fostered innovation in treatment technologies among local industries.s

D. Comparing Regional Treatment Standards

Treatment standards vary significantly across regions, reflecting local environmental conditions and regulatory priorities. In the United States, the Environmental Protection Agency sets baseline standards, but states can enforce stricter rules.

The European Union maintains uniform standards across member states through the Water Framework Directive. This approach ensures consistency but can be challenging for countries with diverse industrial landscapes.

In contrast, China has recently tightened its wastewater regulations, introducing the strictest standards in its history. This move aims to address severe water pollution issues in rapidly industrializing areas.

Japan takes a unique approach by setting effluent standards based on the receiving water body’s intended use, rather than applying blanket limits.

E. Regulations and Compliance

Industrial wastewater treatment is subject to strict rules and oversight. Companies must follow guidelines, adopt best practices, and work with agencies to ensure proper management.

F. Understanding Local and International Guidelines

Wastewater regulations vary by location. In the U.S., the Clean Water Act sets national standards. States and cities may have additional requirements.

International guidelines, like those from the World Health Organization, provide a framework for countries without robust regulations.

Key areas of focus include:

- Discharge limits for pollutants
- Monitoring and reporting requirements
- Treatment technology standards
- Permitting processes

Companies must stay updated on changing rules. Regular audits help ensure ongoing compliance.

G. Industry Best Practices for Compliance

Adopting best practices helps facilities meet or exceed regulatory standards. Key strategies include:

- Regular staff training on compliance procedures
- Implementing robust monitoring systems
- Conducting internal audits
- Upgrading treatment technologies as needed

Wastewater operators play a crucial role in maintaining compliance. They must be well-trained in proper sampling techniques, process control, and recordkeeping.

Proactive maintenance of treatment systems helps prevent compliance issues. This includes regular equipment checks and prompt repairs.

H. The Role of Regulatory Agencies in Wastewater Management

Regulatory agencies enforce wastewater rules and provide guidance. In the U.S., the Environmental Protection Agency (EPA) leads these efforts.

Agency responsibilities include:

- Setting and updating standards
- Issuing permits
- Conducting inspections
- Enforcing penalties for violations

The EPA offers resources for wastewater operators to help facilities stay compliant. These include tip sheets and training materials.

Agencies also work with industries to develop new treatment technologies. This collaboration aims to improve wastewater management practices over time.

I. Future Directions in Wastewater Treatment

Wastewater treatment is evolving rapidly. New technologies, sustainability efforts, and ongoing research are reshaping how we manage and clean wastewater. These advances promise more efficient and eco-friendly treatment methods.

J. Innovations Shaping the Future of Treatment Technologies

Advanced membranes are improving filtration in wastewater treatment. These membranes can remove tiny particles and even some dissolved substances. Nanotechnology is also being used to develop better treatment methods.

Artificial intelligence and machine learning are making treatment plants smarter. These tools can:

- Optimize chemical dosing
- Predict equipment failures
- Adjust processes in real-time

Ultraviolet light and ozone treatments are becoming more common. They can kill harmful microbes without using chemicals. This makes the treatment process safer and more eco-friendly.

K. Sustainability and Wastewater Treatment

Energy recovery from wastewater is gaining traction. Some plants now capture biogas from sewage to generate electricity. This helps offset the energy used in treatment.

Water reuse is becoming more important. Advanced treatment methods can make wastewater clean enough to use again. This helps conserve water resources.

Nutrient recovery is another growing trend. Phosphorus and nitrogen can be extracted from wastewater and used as fertilizers. This turns waste into a valuable resource.

Green infrastructure is being used to manage stormwater. Rain gardens and permeable pavements help filter water naturally. This reduces the load on treatment plants during heavy rains.

L. Experimental methods and equipment

Samples were collected manually. The pH was measured on the spot and the TSS and COD were measured in the laboratory within 24 h after sample collection.

Effluent pH was measured using a Hach pH meter. COD was determined by closed reflux method using a Hach COD reactor (model 45600) followed by calorimetric determination of Cr3+ at a wavelength of 620 nm using a Hach spectrophotometer (model DR 2010). The TSS were determined by measuring the amount of light scattered by the solids at a wavelength of 810 nm, using a Hach spectrophotometer (model DR 2010) The effluent was collected in sterilized plastic container from the outlet of effluent treatment plant of a galvanizing. Industrial wastewater treatment plays a crucial role in protecting the environment and public health. Companies need to carefully monitor and sample their wastewater to ensure proper treatment. Monitoring and sampling methods are key to identifying pollutants and determining the right treatment approach. Effective monitoring involves regular testing of wastewater streams. This helps identify any changes in composition or concentration of contaminants. Sampling techniques vary based on the type of waste and treatment processes used. Grab samples provide a snapshot of water quality at a specific time. Composite samples, collected over a longer period, give a more complete picture of overall wastewater characteristics.

Proper monitoring and sampling allow treatment plants to adjust their processes as needed. This ensures compliance with environmental regulations and protects local water resources. It also helps companies optimize their treatment systems, potentially saving money and resources in the long run.

Key Takeaways
- Regular monitoring and sampling are essential for effective industrial wastewater treatment
- Different sampling methods provide varied insights into wastewater composition and quality
- Proper monitoring ensures regulatory compliance and helps optimize treatment processes.

M. Overview of Industrial Wastewater Treatment

Industrial wastewater treatment involves multiple stages to remove contaminants and protect water resources. Key processes include pretreatment, core treatment technologies, and advanced monitoring methods.

N. Wastewater Pre-treatment: The First Line of Defence

Pretreatment removes large debris and adjusts wastewater properties before main treatment. Screens and filters catch solids like plastic, rags, and wood. Grit chambers allow sand and other heavy particles to settle out.

pH adjustment neutralizes acidic or alkaline wastewater. This protects downstream equipment and biological processes. Oil and grease removal uses skimmers or dissolved air flotation.

Equalization tanks balance flow and pollutant concentrations. This improves treatment efficiency. Some facilities use chemical precipitation to remove metals and other pollutants.

O. Core Treatment Technologies

Biological treatment breaks down organic matter using microorganisms. Activated sludge is a common method that uses aeration tanks and clarifiers. Fixed film processes like trickling filters and rotating biological contactors are also used.

Physical-chemical treatments remove specific contaminants. These include:
- Carbon adsorption
- Ion exchange
- Membrane filtration

Advanced oxidation uses chemicals or UV light to destroy toxic compounds. Anaerobic digestion treats high-strength waste and produces biogas. Online sensors now provide real-time data on flow, pH, dissolved oxygen, and other parameters. This allows quick responses to changes in wastewater quality.

Automatic samplers collect representative samples over time. These devices can be programmed for different sampling schedules.

New portable field testing kits give rapid results for many pollutants. DNA- based methods can identify specific microorganisms in biological treatment systems.

Data management software helps analyze trends and optimize treatment processes. Remote monitoring allows operators to check plant status from anywhere.

P. Monitoring and Sampling Methods

Effective monitoring and sampling are crucial for industrial wastewater treatment. These methods ensure compliance with regulations and help optimize treatment processes.

On-site vs. Off-site Analysis

tOn-site analysis offers quick results and real-time data. It allows for immediate adjustments to treatment processes. Portable equipment like pH meters and conductivity probes are common tools.

Off-site analysis involves sending samples to a laboratory. This method provides more detailed and accurate results. It’s useful for complex tests that require specialized equipment.

Some facilities use a combination of both approaches. This balances the need for speed with the desire for in-depth analysis.

Q. Automatic Monitoring Technologies

Continuous monitoring systems are becoming more common in industrial settings. These systems can measure parameters like pH, temperature, and dissolved oxygen 24/7.

Online analyzers can detect specific pollutants in real-time. They often use techniques like spectrophotometry or ion-selective electrodes.

Data loggers record and store information over time. This allows for trend analysis and helps identify long-term issues.

Remote monitoring technologies enable off-site supervision. They can send alerts if parameters exceed set limits.

R. Sampling Protocols and Procedures

Proper sampling is crucial for accurate wastewater analysis. Samples must be representative of the entire wastewater stream.

Grab samples are taken at a specific time and location. They’re useful for monitoring short-term changes or spikes in pollutant levels.

Composite samples are collected over time. They provide a more comprehensive picture of average wastewater composition.

Sample preservation is often necessary to maintain integrity. This may involve cooling, adding chemicals, or adjusting pH.

Chain of custody procedures ensure sample traceability. They document who handled the sample and when.

S. *Treatment and Disinfection Systems*

Industrial wastewater treatment uses various methods to clean and disinfect water before release. These systems employ chemical, physical, and biological processes to remove contaminants and kill harmful microorganisms. New technologies continue to improve treatment effectiveness and efficiency.

T. Chemical and Physical Disinfection Processes

Chemical disinfection is a key step in industrial wastewater treatment. Common chemicals used include chlorine, ozone, and ultraviolet light. Chlorine is cost-effective but can create harmful byproducts. Ozone is powerful but expensive. UV light is safe but less effective on cloudy water.

Physical processes also play a role. Filtration removes particles and microorganisms. Membrane technologies like reverse osmosis can remove even tiny contaminants. Heat treatment kills pathogens but uses a lot of energy.

The choice of disinfection method depends on:

- Water quality
- Treatment goals
- Cost
- Safety concerns

U. Biological Treatment Techniques

Biological treatment uses microorganisms to break down organic matter in wastewater. Activated sludge is a common method. It involves adding oxygen to wastewater to promote bacterial growth. The bacteria consume pollutants, cleaning the water.

Other biological techniques include:

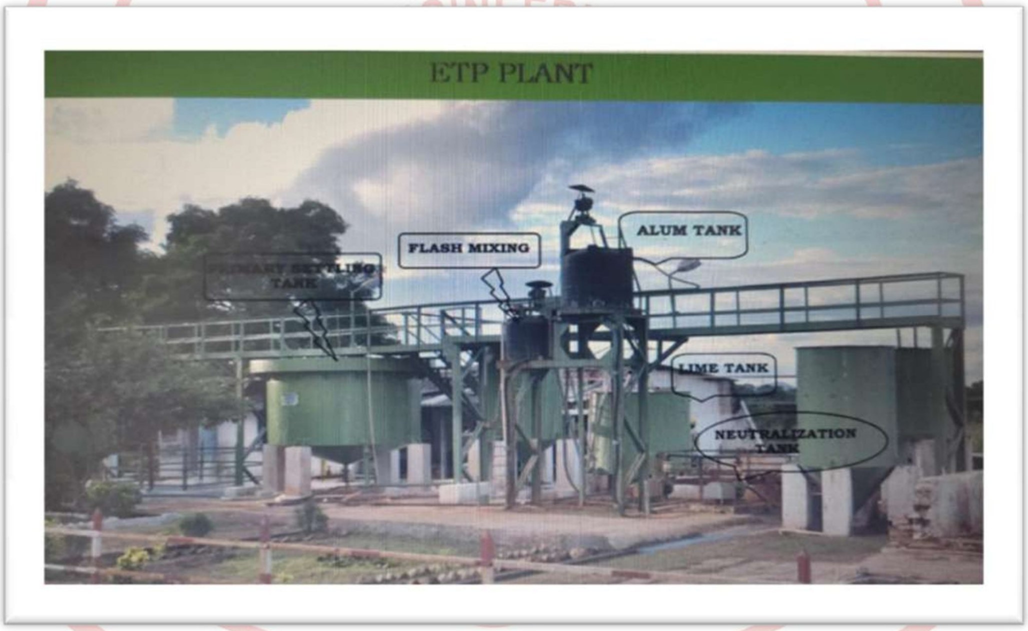
- Trickling filters
- Rotating biological contactors
- Anaerobic digestion

These methods can remove up to 95% of organic pollutants. They're eco- friendly but require careful monitoring and control.

III. CHARACTERISTICS OF GALVANISING UNIT

A. Galvanizing Processes

The electroplating industry is concerned with coating metallic and non-metallic parts with a thin layer of a more noble metal than the basic one, through chemical changes produced by the electric current. In general, this process is carried out in a reactor, where a determined electrolyte is stored so that the electrical energy is transferred by an anode, providing it with ions in solution.



a. Preparation Of The Piece Surface And Degreasing

In this operation, the piece surface is prepared by removing burrs and rough points, to create the conditions for subsequent chemical treatment of the optimum surface, for chemical adhesion of the metals to be coated.

Degreasing can be carried out at two levels:

- macro degreasing where heavy fats are removed and
- micro degreasing where refining process occurs with fats that form adhesion films

Greases and oils found on the metallic pieces are removed from their surface. The pieces are treated by immersion while using the minimum agitation to avoid deformations or breaks. The pieces need to be able to be cleaned well for later treatments of nit riding surface oxidation or the electroplating processes themselves.

b. Immersion treatments with alkali

Fat removal by immersion in strong bases, e.g. NaOH or KOH. This can be done at high temperatures. Over time, this bath produces a residue that has to be neutralized with oils in solution and metallic sludge. These treatments require subsequent rinsing baths to remove the salts resulting from the saponification reactions.

This leads to emulsification of the fluids, which requires bath changes, water recharges, and an emphasis on the "time" factor in the whole process.

Degreasing may be impaired in parts or loads with positional impediments, complex geometries, highly porous materials or sintered metals. Normally these baths are additive.

c. Surfactants

These are used in addition to alkaline solutions as neutral non-ionic degreasers. Their effect is produced by the formation of micelles and they are mostly used in spray systems.

Their main disadvantages lie in the difficulty of interacting with pieces with difficult geometries, sintered materials or loads with positional impediments that prevent easy access of the degreaser to the interior of the load, as well as the ability to emulsify oils and polluting fluids; thus, frequent bath changes are required.

d. Degreasing by organic solvents

Chlorinated organic solvents have traditionally been used in these types of baths. Different EU directives impose limits on their use due to their climate change impact. These solvents dissolve fats and leave the metal parts practically dry. They do not attack the piece or alter the material coloration. These organic solvents can be recovered by distillation.

Electrolytic degreasing with alkalis

This is one of the most effective degreasing procedures. A strongly alkaline electrolyte is used with the help of the cathode electrical current and rarely the anode. Organic chlorine dispersants and strong alkalis are used which have a VOC problem.

Due to the use of organic chlorine solvents being prohibited, these are currently being replaced by:

- Paraffin solvents (VOC): These are volatile and flammable organic compounds which require special safety controls.
- Oxygenated solvents: These are compounds that have a flammability and toxicity problem. They are compatible with many solvents used in paints.
- Fluorinated solvents: Like most chlorinated solvent-based products, most are non-flammable except when mixed with other solvent types and highly volatile, with the products being more like chlorinated solvents. They have the disadvantage of a highly specific application due to their solubility and high vapour pressure. This series of factors impact on their cost.
- Paraffin solvents (non-VOC): These are high boiling point paraffin solvents and so are not VOCs. A special application is to use them as an intermediate process, since their excellent cleaning capacity, low volatility and viscosity, together with the possibility of making them emulsifiable, mean they can be easily removed with water-based processes and systems.

Degrease washing

This is washing the pieces after the previous phase with water, to remove irregular stains or deposits on their surface. Water is used in this stage with the result that waste from the previous stage is incorporated.

e. Pickling

Deoxidation process

Its purpose is to remove the oxides present on the piece surface. Pickling can be carried out in an acid or alkaline bath.

The basic solutions used are hydroxides (sodium, potassium or calcium) and carbonates (sodium carbonate), organic and inorganic additives and surfactants. The acid solutions used may be sulfuric, hydrochloric or, in certain cases, hydrofluoric acid. As a result of this stage, sewage and sludge are formed from the removal of the oxides.

View of Pickling & Scrubber

Pickling plant

Scrubber Units

This consists of rinsing the metallic or plastic pieces in a tank with water to prevent the carryover of acid to the following process stages. Contaminated wastewater is produced from the pickling process.

The object is to remove any acid remaining from the previous process and to prevent subsequent oxidation of the pieces. The wastewater obtained is rinsing water for the neutralization treatment.

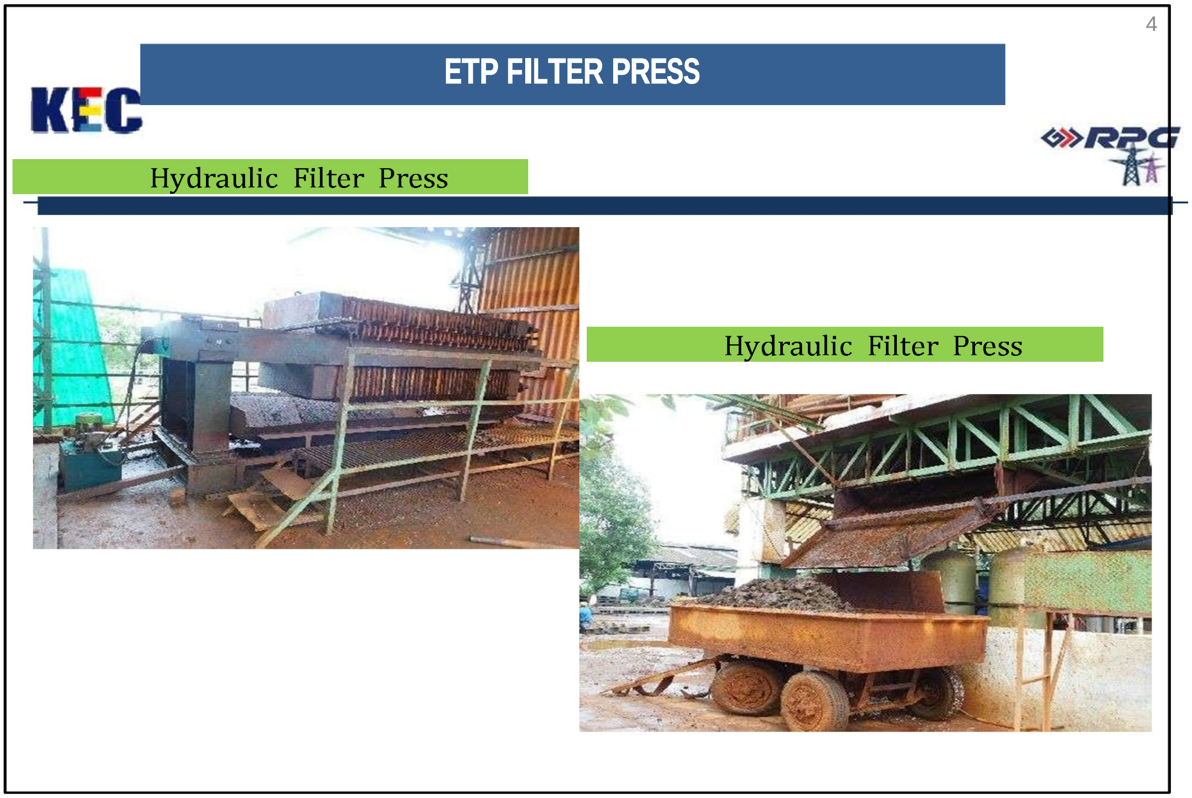
f. Mechanical preparation of the piece

This consists of preparing the piece to leave it smooth, polished and bright to facilitate deposition of another layer of metal on the surface.

This stage is important for the good quality of the piece. This is divided into roughing, grinding and polishing. Roughing is done by abrasive discs of different sizes and hardness, refined with grain or with medium structure ceramics.

Grinding can be done by hard disks of medium structures or ceramic medium structures. The polishing can be mechanical or electrolytic by brines that work the surface of the metal leaving it shiny.

For this stage of the process, sulfuric, phosphoric, chromic, nitric and citric acids or combinations of them are used for the case of electrolytic polishing, as well as cooling water to prevent overheating of the heat-sensitive parts.



4

ETP FILTER PRESS

Hydraulic Filter Press

Hydraulic Filter Press

The waste produced in this stage is basically the packaging for the chemicals used, hot water, particulate polishing material and very acid metallic salt solutions, with chromium (VI) being particularly important in the case of chromium.

g. Physical Cleaning

Removal of particles that remain in the form of lumps on the metal parts. This stage requires cleaning materials (of wool or synthetic fibers) and water at room temperature to remove particles difficult to separate.

i. Electrolysis

The electrolyte coating is properly produced in this stage. The pieces, fixed like the cathode, are covered with the appropriate metal, leaving some sludge from the metal deposition, the salts and the reduction oxide processes that take place at the cathode and anode - production of oxygen and hydrogen.

To perform this task, metallic coating materials, such as sulphates, chlorides, nickel cyanides, chromium and tin are used. Additional chemical agents are also used, such as sodium naphthalene trisulfonate and formaldehyde.

The waste produced is mainly liquid waste from the nickel, chromium and tin solutions, additivated solutions, cyanide solutions and empty chemical containers.

ii. Hot Washing

The piece is washed with a dilute hydrochloric acid solution, producing an acidic residual solution.

iii. Drying and oiling

The metal pieces must be dried after the electrolytic process to prevent staining on the metallic deposits produced. The drying process can be carried out on drying supports, in drying ovens or by spraying with air at high temperature, 80- 90°C to remove surface humidity.

Then, a thin layer of oil is applied to the metallic piece to protect it from humidity and to prevent oxidation. This process is carried out by means of an electrostatic oiling process.

h. Zinc plating process in strongly acidic medium

Electro-galvanized coatings (electroplating) are created by applying zinc to the steel sheet and stripping by electrode position. As with the galvanized sheet, the operation is continuous, and the coating thickness is minimal.

For a steel rolling plant, the sheet or strip is entered with the appropriate equipment in a series of washes and rinses, then in the zinc bath.

Grain refiners can be added to help produce a uniform and well-bonded zinc coating on the steel. Electroplating is applied to steel sheets and wires, and are therefore used in applications similar to galvanizing a continuous sheet or wire.

The most common applications are in the automotive industry and equipment mountings and fasteners. In addition, to extending service life, electroplating can be done to make the coating suitable for painting, and this is often recommended due to the extremely thin zinc coating.

The galvanizing process begins with degreasing by chemical methods,:

- By saponification of possible oils by bases
- By electrolysis procedures.

The resulting solutions require neutralization and emulsion treatment, if produced. Afterwards, the piece is rinsed to remove alkalis and to prevent the effect of subsequent acids being diminished during pickling.

Once this superficial layer of oil or other surface deposits has been removed, pickling is carried out. Chemical pickling occurs with strong acids under controlled periods. The objective is to remove oxides or other coatings that may have formed circumstantially on the piece.

This bath produces a strongly acid solution with salts from the attack of oxides, sulfates and iron chlorides. To avoid further deposition, complexing agents such as EDTA are used for iron and other metals. This dissolution leaves the piece ready for the electrolytic process.

B. Governing Specification

ASTM B633, lists four classes of zinc electroplating:

Fe/Zn 5, Fe/Zn 8, Fe/Zn 12 and Fe/Zn 25, where the number indicates the thickness coating in microns (µm).

In the electrolytic deposition process, metallic zinc is deposited at the anode and hydrogen released. More complex effects are produced at the cathode, such as:

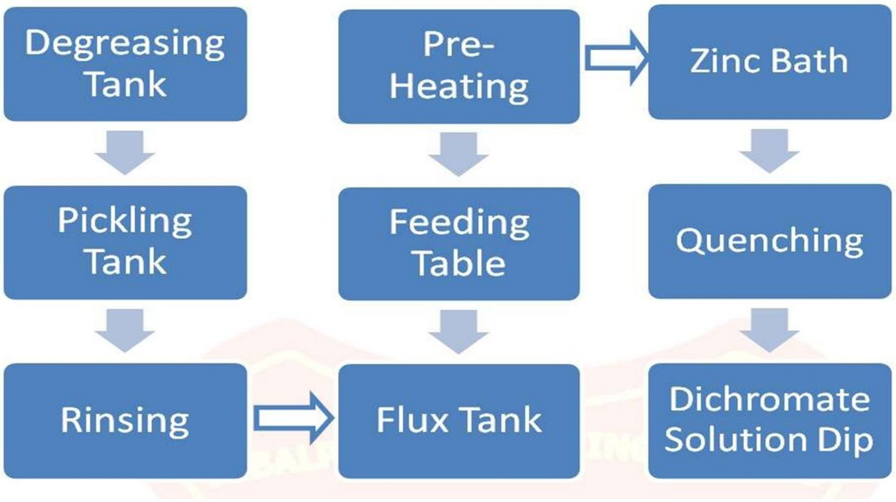
- Oxidation from SO_4^{2-} to $S_2O_8^{2-}$
- Decomposition of $S_2O_8^{2-}$ to SO_4^{2-} and SO_3^{2-}, producing oxygen as a by- product.
- Synthesis of H_2SO_4
- Decomposition of water with oxygen production.

After electrolysis, another rinse and transfer to the passivation process is necessary to produce a protective layer on the piece. Strong acids such as chromic and sulfuric, are used in this process.

For steels, the ASTM A380 and ASTM A967 standards cover a wide range of descaling and passivation cleaning processes for stainless steel parts, equipment and systems, as well as chemical passivation treatment specifications for stainless steel parts.

In the case of zinc, depending on the electrodeposition residence time, the bath pH, stirring and the temperature, different passivation structures will be obtained, such as passivated bluish iridescence (zinc-plated rainbow), passivated (olive color), passivated (zinc-plated iris) and passivated black zinc.

The most common electrolyte/zinc anode arrangement uses lead/silver or other insoluble anodes and zinc sulfate electrolytes. Soluble pure zinc anodes are also used. The coating develops as the positively charged zinc ions in the solution are reduced by electricity to zinc metal and deposited on the positively charged cathode (steel sheet).The temperature ranges are between 18 and 30°C. After the passivation process, a rinse removes reagents and drying is performed.



Sources Of Effluent

There are two common galvanization methods

- Hot dip method and
- Electrolytic methods

The hot dip method is predominant in utility specially for galvanization of large size materials. During this process the mild steel materials are subjected to series of treatments including initial cleaning by bathing in acids, in water and in alkali followed by baths in molten lead, in ammonium compound ,in molten zinc and finally washed in hot water.

Later, the materials are packaged and dispatched to market. The effluent is generated from the bathing, washing and cooling units and is almost regular in flow. The bathing units are emptied for the rejection of liquors as effluent after they assume the limiting concentration of raw materials. The volume of affluent depends upon the nature and quantity of product of galvanization.

IV. METHODOLOGY

A. *Materials and Methods*

Monitoring of effluent discharges from industrial establishments discharging directly into municipality sewers is one of the major water pollution control activities conducted by municipalities. For largely industrialised municipalities, the task can be quite expensive and not effective if sampling programmes are not properly designed.

In most cases, samples are randomly collected without proper knowledge of the discharge patterns of various industries. As a result, the information obtained does not give a good reflection of the quality of effluent being discharged.

Methods

These problems can be resolved by adapting a statistical approach to the design of sampling programmes. This approach is useful in determining the frequency of sampling, the number of samples needed to estimate the average concentration of target pollution indicator parameters and the magnitude of the uncertainty involved.

The sampling programme was divided into two phases.

The first phase lasted for 2 months and was designed to simulate random sampling data. Five snap samples were collected on each 8-h day work shift after a time interval of 1.5 h. Samples were collected from each industry after a 1-day time interval during the 2-month period, ensuring that sampling was done twice per each specific day of the week in each sampling month. The objective of this phase was to build an understanding of the variation of the effluent quality over time and thus provide data for the statistical design of the sampling programme. The objective of the second phase was to establish pollution trends and monthly means of the major pollutant parameters. Four samples were systematically collected per month from each industry for a period of 3 months, based on the results obtained in the first phase. Four industries were used as case studies, namely the tannery, textile finishing, sugar refining and sugar confectionery industrial sectors. The major pollution indicator parameters considered were the pH, total suspended solids (TSS) and chemical oxygen demand (COD).

Industrial effluent sampling involves collecting representative samples of wastewater discharged from industrial facilities to assess its quality and ensure compliance with environmental regulations. This process typically includes identifying sampling locations, choosing appropriate methods, collecting samples, preserving and transporting them, and analyzing them for relevant parameters. Here's a more detailed breakdown of the process:

1) Identifying Sampling Locations

- Permit Requirements:

Samples should be collected at the site specified in the permit, or if no site is specified, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters.

- Homogeneity:

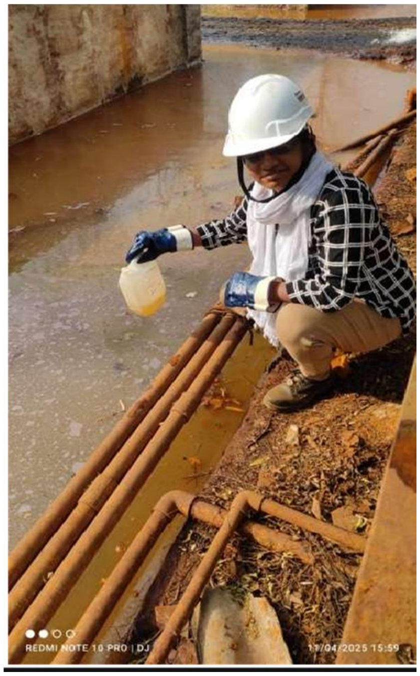
Consider the homogeneity of the water or wastewater, as the composition can vary horizontally and vertically, as well as over time.

- Sampling Points:

Consider sampling locations upstream and downstream of industrial and domestic discharge points, at places of abstraction for industrial use and public water supply, and at baseline stations where water is available in its natural state.

2) Choosing Appropriate Sampling Methods:

- Grab Samples: These are individual samples collected at a specific time and location.
- Composite Samples: These are made up of multiple grab samples collected over a specific period, either at regular intervals or proportionally to the flow rate.
- Flow-Proportional Sampling: This method collects samples in proportion to the flow rate, ensuring a more representative sample of the effluent.
- Time-Composite Sampling: This method collects samples at regular intervals over a specific period.



3) Collecting Samples

- Equipment: Use appropriate sampling equipment, such as bottles, containers, and samplers, to ensure the integrity of the samples.
- Procedure: Follow established sampling procedures to minimize contamination and ensure accurate results.
- Documentation: Document all aspects of the sampling process, including location, time, date, and any relevant observations.

4) Preserving and Transporting Samples:

- Preservation: Use appropriate preservatives to prevent degradation of the samples during storage and transport.
- Transportation: Transport samples to the laboratory promptly and in a manner that maintains their integrity.
- Chain of Custody: Maintain a chain of custody to ensure the integrity of the samples throughout the sampling and analysis process.

5) Analyzing Samples:

- Analytical Methods: Use appropriate analytical methods to determine the concentration of pollutants in the samples.
- Parameters: Analyze samples for relevant parameters, such as pH, total suspended solids (TSS), chemical oxygen demand (COD), and other pollutants.
- Quality Assurance: Implement quality assurance procedures to ensure the accuracy and reliability of the analytical results.

6) Interpreting Results and Reporting:

- Data Interpretation: Interpret the analytical results in the context of regulatory standards and environmental conditions.
- Reporting: Report findings to regulatory agencies and other stakeholders.
- Compliance: Use the data to demonstrate compliance with environmental regulations and to identify areas for improvement in effluent treatment.

Key Considerations for Industrial Effluent Sampling:

- Statistical Design: Use a statistical approach to design sampling programs to ensure that the samples are representative of the effluent.
- Sampling Frequency: Determine the appropriate frequency of sampling based on the variability of the effluent and the regulatory requirements
- Sampling Port Design: Ensure that the sampling port is properly designed to collect a representative sample of the effluent.
- Third-Party Certification: Consider using independent third-party certifiers to conduct performance evaluation and accurately measure system performance in a standardized, reproducible setting.

B. Tests And Sop

Principle:

TEST 1 : SOP FOR CHLORIDE ARGENTOMETRIC METHOD

In a neutral or slightly alkaline solution, potassium chromate can indicate the end point of the silver nitrate titration of chloride. Silver chloride is precipitated quantitatively before red silver chromate is formed.

Interference:

1. Substances in amounts normally found in potable waters will not interfere. Bromide, iodide, and cyanide register as equivalent chloride concentrations. Sulfide. thiosulfate and sulfite ions interfere but can be removed by treatment with hydrogen peroxide. Orthophosphate in excess of 25 mg/L interferes by precipitating as silver phosphate. Iron in excess of 10 mg/L interferes by masking the end point.
2. Detectable limit: The argentometric method is suitable for use in relatively clear waters when 0.15 to 10 mg Cl are present in the portion titrated.

Apparatus

- Erlenmeyer flask, 250 mL.
- Buret, 50 mL.

Reagents

- Potassium chromate indicator solution: Dissolve 50g K2CrO4 in a little distilled water. Add AgNO3 solution until a definite red precipitate is formed. Let stand 12h, filter, and dilute to 1L with distilled water.
- Standard silver nitrate titrant, 0.0141M (0:0141N): Dissolve 2.395g AgNO; in distilled water and dilute to 1000 mL. Standardize against NaCl; 1.00 mL = 500 ug Cl-. Store in a brown bottle.
- Standard sodium chloride, 0.0141M (0.0141M): Dissolve 824.0 mg NaCl (dried at 140 C) in distilled water and dilute to 1000 mL: 1.00 mL = 500-µg Cld.

Special reagents for removal of interference

- Aluminum hydroxide suspension: Dissolve 125g aluminum potassium sulfate or aluminum ammonium sulfate. AIK (SO,) 2.12H2O) or AINH.(SO,) 2. 12H.O. ir. 1L distilled water. Warm to 60°C and add 55 mL conc. ammonium hydroxide (NH.OH) slowly with stirring. Let stand about 1 h, transfer to a large bottle and wash precipitate by successive additions with thorough mixing and decanting with distilled water, until free from chloride. When freshly prepared, the suspension occupies volume of approximately 1 L.
- Phenolphthalein indicator solution.
- Sodium hydroxide, NaOH, IN.
- Sulfuric acid H2SO4, 1 N.
- Hydrogen peroxide, H_2O_2, 30%

Procedure

a. Sample preparation:

Use a 100 mL sample or a suitable portion diluted to 100 mL. sample is highly colored add 3 mL Al_2 (OH) $_3$ suspension, mix, let settle and filter. If sulfide, sulfite, or thiosulfate is present, add 1 mL H_2O2 and stir for 1 min.

b. If the Titration:

Directly titrate samples in the pH range 7 to 10. Adjust sample pH to 7 to 10 wrth H_2SO, or NaOH if it is not in this range. For adjustment, preferably use a pH meter with a non- chloride-type reference electrode.

(If only a chloride-type electrode is ava:lable. determine amount of acid or alkali needed for adjustment and discard this sample portion Treat a separate portion with required acid or alkali and continue analysis)

Add10Rl K2Cr2O_7 indicator solution. Titrate with standard $AgNO_3$, titrant to a pinkish yellowend point. Be consistent in end- point recognition. Standardize $AgNO_3$ titrant and establish reagent blank value by the titration method outlined above. The value of blank is generally of 0.2 to 0.3 ml

Calculation

(A-B) x Nx35450 Mg Cl-/L = mL. sample Where:

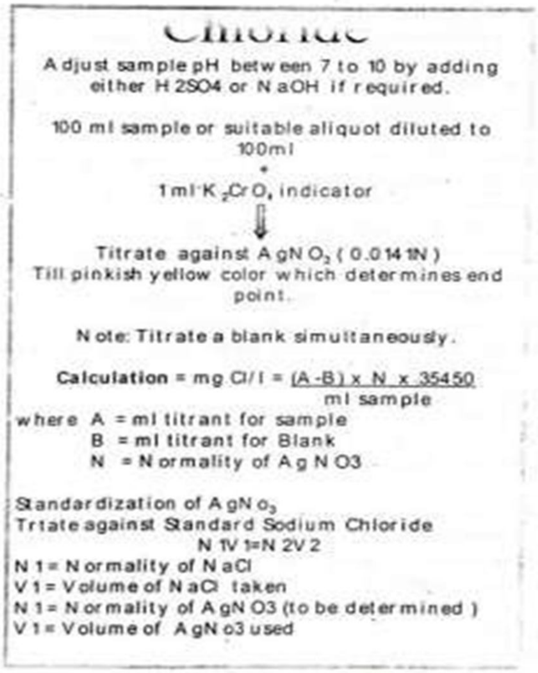
A = mL. titration for sample.

B = mL titration for blank, and N = Normality of $AgNO_3$.

Precision and Bias

Mg NaCI/L = (mg C1-/L) x 1.65

A synthetic sample containing 241 mgCl-/L, 108 mg Ca/L, 82 mg Mg/L;
3.1 mg K/L, 19.9 mg Na/L, 1.1 mg NO_3- N/L 0.25 mg NO2- N/L, 259 mg
SO,2/L and 42.5 mg total alkalinity/L (contributed by NaHCO,) in distilled water was analyzed in 41 laboratories by the argentometric method, with a relative standard deviation of 4.2% and a relative error of 1.7%.



Chloride

Adjust sample pH between 7 to 10 by adding either H 2SO4 or NaOH if required.

100 ml sample or suitable aliquot diluted to 100ml

\+

1ml K_2CrO_4 indicator

⇓

Titrate against $AgNO_2$ (0.0141N)
Till pinkish yellow color which determines end point.

Note: Titrate a blank simultaneously.

Calculation = mg Cl/l = $\frac{(A-B) \times N \times 35450}{\text{ml sample}}$

where A = ml titrant for sample
B = ml titrant for Blank
N = Normality of AgNO3

Standardization of $AgNo_3$
Trtate against Standard Sodium Chloride
N 1V 1=N 2V 2
N 1= Normality of NaCl
V 1= Volume of NaCl taken
N 1= Normality of AgNO3 (to be determined)
V 1= Volume of AgNo3 used

TEST 2: SOP FOR FLUORIDE SPADNS METHOD

Principle:
The SPADNS colorimetric method is based on the reaction between fluoride and a zirconium-dye lake, Fluoride reacts with the dye lake, dissociating a portion of it into a colorless complex anion and the dye. As the amount of fluoride increases, the color produced becomes progressively lighter.

The reaction rate between fluoride and zirconium ions is influenced greatly by the acidity of the reaction mixture. If the proportion of acid in the reagent is increased, the reaction can be made almost instantaneous. Under such conditions however, the effect of various ions differs from that in the conventional alizarin methods. The selection of dye for this rapid fluoride method is governed largely by the resulting tolerance to these ions.

Interference:
Whenever any one substance is present in sufficient quantity to produce an error of 0.1 mg/L or whenever the total interfering effect is in doubt distill the sample. Also distill colored or turbid samples. In some instances, sample dilution or adding appropriate amounts of interfering substance to the standards may be used to compensate for the interference effect. If alkalinity is the only significant interference neutralize it with either hydrochloric or nitric acid.

Chlorine interferes and provision for its removal is made. Volumetric measurement of sample and reagent is extremely important to analytical accuracy. Use samples and standards at the same temperature or at least within 2°C. Maintain constant temperature throughout the color development period. Prepare different calibration curves for different temperature ranges.

- Detectable range: 0-1.40mg/L. Apparatus Colorimetric equipment: One of the following is required:
- Spectrophotometer, for use at 570 nm, providing a light path of at least 1 cm.
- Filter photometer, providing a light path of at least 1 cm and equipped with a greenish yellow filter having maximum transmittance at 50 to 580 nm.

Reagents

Standard fluoride solution :

Dilute 100 ml stock fluoride solution (dissolve 221.0 mg sodium fluoride in 1000 ml distilled water, 1.0 ml = 100 µg) to 1000 ml with distilled water: 1ml = 10.0 µg F.

SPADNS solution: Dissolve 958 mg SPADNS, sodium 2- (parasulfophenylazo)-1, 8 dihydroxy-3. 6- naphthalene disulfonate, also called 4, 5- dihydroxy-3(parasulfophenylazo) 2, 7- naphthalendedisulfonic acid trisodium salt; in distilled water and dilute to 500 mL. This solution is stable for at least 1 year if protected from direct sunlight.

Zirconyl-acid reagent:

Dissolve 133 mg zironyl chloride octahydrate, ZrOCl2. 8H□O, in about 25 mL distilled water. Add 350 mL conc HC1 and dilute to 500 mL with distilled water. d. Acid zirconyl-SPADNS reagent: Mix equal volumes of SPADNS solutin and zirconyl-acid reagent. The combined reagent is stable for at least 2 years. Reference solution: Add 10 mL SPADNS solutin to 100 mL distilled water. Dilute 7 mL conc HCI to 10 mL and add to the diluted SPADNS solution. The resulting solution, used for setting the instrument reference point (zero) is stable for at least 1 year.

Procedure

- Preparation of standard curve: Prepare fluoride standards in the range of 0 to 1.40 mg F-/L by diluting appropriate quantities of standard fluoride solution to 50 mL with distilled watr. Pipet 5.00 mL each of SPADNS solution and zirconyl-acid reagent, or 10.00 mL mixed acidzirconyl-SPADNS reagent to each standard and mix well. Avoid contamination.
- Plot a curve of the milligrams fluoride-absorbance relationship. Prepare a new standard curve whenever a fresh reagent is made or a different standard temperature is desired. b. Sample pretreatment: If the sample contains residual chlorine remove it by adding 1 drop (0.05 mL) NaAsO2 solution 0.1 mg residual chlorine and mix. (Sodium arsenite concentrations of 1300 mg/L produce an error of 0.1 mg/L at 1.0 mg F-/L)
- Color development: Use a 50.0 mL sample or a portion diluted to 50 mL with distilled water. Adjust sample temperature to that used for the standard curve. Add 5.00 mL each of SPADNS solution and zirconyl-acid reagent, or 10.00 mL acid zirconyl-SPADNS reagent: mix well and read absorbance, first setting the reference point of the photometer as above. If the absorbance falls beyond the range ofthe standard curve, repeat using a diluted sample.

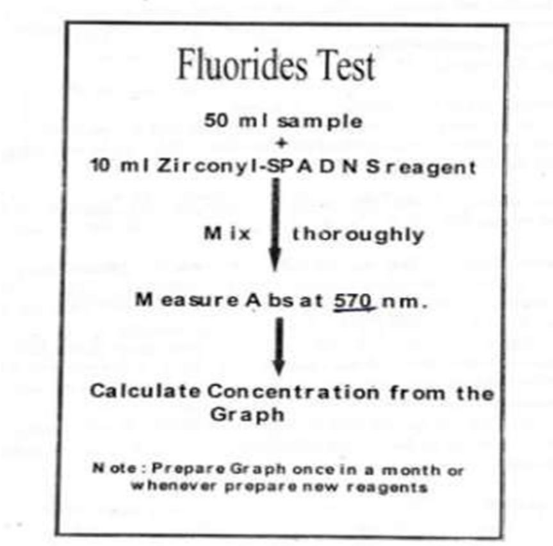
Calculation

Where: A B mg F-/L -- x --- mL sample C

A = µg F- determined from plotted curve.

B = final volume of diluted sample, mL and C = volume of diluted sample used for color development mL.

Principle:



TEST 3 : SOP OF PH ELECTROMETRIC METHOD

The basic principle of electrometric pH measurement is determination of the activity of the hydrogen ions by potentiometer measurement using a standard hydrogen electrode and a reference electrode. The hydrogen electrode consists ofa platinum electrode across which hydrogen gas is bubbles at a pressure of 101 kPa. Because of difficulty in its use and the potential for poisoning the hydrogen electrode, the glass electrode commonly is used.
The electromotive force (emf) produced in the glass electrode system varies linearly with pH. This linear relationship is described by plotting the measured emf against the pH of different buffers. Sample pH is determined by extrapolation.

Interferences:
The glass electrode is relatively free from interference from color, turbidity, colloidal matter, oxidants, reluctant, or high salinity, except for a sodium error at pH> 10. Reduce this error by sunig special "low sodium error" electrodes.

Apparatus & Reagents

- pH measurements are affected by temperature in two ways: mechanical effects that are caused by changes in the properties of the electrodes and chemical effects caused by equilibrium changes. In the first instance, the Nernstian slope increases with increasing temperature and electrodes take time to achieve thermal equilibrium. This can cause longterm drift in pH.
- Because chemical equilibrium affects pH, standard pH buffers have a specified pH at indicated temperatures. Always report temperature at which pH is measured. pH meter consisting of potentiometer, a glass electrode a reference electrode, and a temperature- compensating device. A circuit is completed through the potentiometer when the electrodes are immersed in the test solution. Many pH meters are capable of reading pH or mill volts and some have scale expansion that permits reading to 0.01 pH unit. but most instruments are not that precise.

General preparation: Calibrate the electrode system against standard buffer solutions of known pH.

- Saturated potassium hydrogen tartrate solution: solution: Shake vigorously an excess (5 to 10g) of finely crystalline KHC4H4O6 with 100 to 300 mL distilled water at 25°C in a glassstoppered bottle. Separate clear solution from undissolved material by decantation or filtration.
- Saturated calcium hydroxide solution: Calcine a well-washed, low- alkali grade CaCO; in a platinum dish by igniting for 1h at 1000°C. Cool, hydrate by slowly adding distilled water with stirring and heat to boiling. Cool filter and collect solid Ca(OH)2 on a fritted glass filter of medium porosity. Dry at 110°C cool and pulverize to uniformly fine granules. Vigorously shake an excess of fine granules with distilled water in a stoppered polyethylene bottle.
- Auxiliary solution: 0.1N NaOH, 0.1N HCI, 5N HCI (dilute five volumes 6N HCI with one volume distilled water), and acid potassium fluoride solution (dissolve 2g KF in 2 mL conc. H□SO4 and dilute to 100 mL with distilled water).

Procedure
Instrument calibration: In each case follow manufacturer's instructions for pH meter and for storage and preparation of electrodes for use.

Sample analysis:
Establish equilibrium between electrodes and sample by stirring sample to insure homogeneity; stir gently to minimize carbon dioxide entrainment. For buffered samples or those of high ionic strength, condition electrodes after cleaning by dipping them into sample for I min.
Blot dry,immerse in a fresh portion of the same sample and read pH. With dilute poorly buffered solutions equilibrate electrodes by immersing in three or four successive portions of sample. Take a fresh sample to measure pH.

Principle:
TEST 4 :SOP FOR TOTAL SOLIDS TOTAL SOLIDS DRIED AT 103-105°C
A well-mixed sample is evaporated in a weighed dish and dried to constant weight in an oven at 103 to 105°C. The increase in weight over that of the empty dish represents the total solids. The results may not represent the weight of actual dissolved and suspended solids in wastewater samples.

Interferences:
Highly mineralized water with a significant concentration of calcium. magnesium, chloride, and/or sulfate may be hygroscopic and require prolonged drying, proper desiccation, and rapid weighing. c. Detectable range: range up to 20 000 mg/L

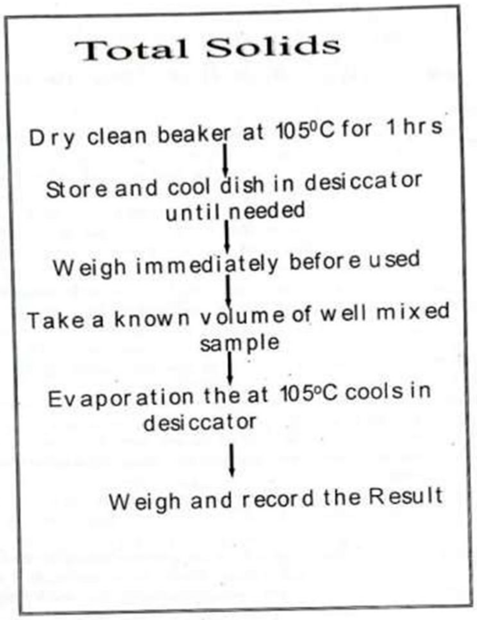
Apparatus
Evaporating dishes:
Dishes of 100 mL capacity made of one of the following materials:

- Porcelain, 90-nm diam.
- Platinum - Generally satisfactory for all purposes.
- High-silica glass. b. Muffle furnace for operation at 550°C.

Steam bath.
Desiccator, provided with a desiccant containing a color indicator of moisture concentration or an instrumental indicator,
Drying oven, for operation at 103 to 105°C.
Analytical balance, capable of weighing to 0.1 mg.
Magnetic stirrer with TFE stirring bar.
Wide-bore pipets. i. Graduated cylinder.

Procedure
Sample analysis:
a. Low-form beaker.
Preparation of evaporating dish: If volatile solids are to be measured ignite clean evaporating dish at 550°C for 1 h in a muffle furnace. If only total solids are to be measured, heat clean dish to 103 to 105°C for 1 h. Store and cool dish in desiccator until needed. Weigh immediately before use.
Choose a sample volume that will yield a residue between 2.5 and 20 gm. Piper a measured volume of well-mixed sample.

Calculation
(A-B) x 1000 mg total solids/L = sample volume, mL Where:
A = weight of dried residue + dish, mg, and
B = weight of dish, mg.



TEST 5: SOP FOR TOTAL SUSPENDED SOLID TOTAL SUSPENDED SOLIDS DRIED AT 103-105C

Principle:

A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and progongs filtration, it may be necessary to increase the diameter of the filter or decrease the sample volume.

To obtain an estimate of total suspended solids calculate the difference between total dissolved solids and total solids.

Interferences:

Exclude large floating particles or submerged agglomerates of nonhomogeneous materials from the sample if it is determined that their inclusion is not representative. Because excessive residue on the filter may from a water entrapping crust, limit the sample size to that yielding no more than 200 mg residue. For samples high in dissolved solids thoroughly was the filter to ensure removal of dissolved material. Prolonged filtration times resulting from filter clogging may produce high results owing to increased colloidal materials captured on the clogged filter.

Apparatus

Apparatus is required except for evaporating dishes steam bath and 180°C drying oven. In addition: Aluminum weighing dishes. Glass-fiber filter disks* without organic binder.

Procedure

Filtration apparatus:

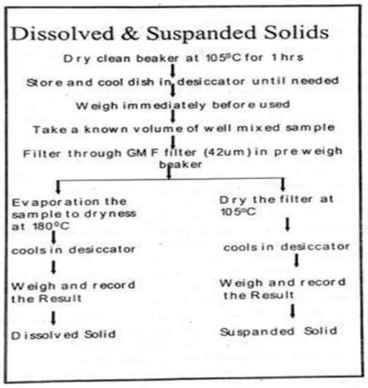
One of the following, suitable for the filter disk selected. Membrane filter funnel. Gooch crubible, 25 mL to 40 mL capacity with Gooch crucible adapter. Filtration apparatus with reservoir and coarse (40 to 60 um) frittd disk as filter support. Suction flask, of sufficient capacity for sample size selected. Drying oven, for operation at 180 + 2°C

a. Preparation of glass-fiber filter disk: If pre-prepared glass fiber filter disks are used, eliminate this step. Insert disk with wrinkled side up in filtration apparatus. Apply vacuum and wash disk with three successive 20 mL portions of reagent-grade water. Continue suction to remove all traces of water turn vacuum off and discard washings. Remove filter from filtration apparatus and transfer to an inert aluminum weighing dish. If a Gooch crucible is used, remove crucible and filter combination. Dry in an oven at 103 to 105°C for 15 min in a muffle furnace. Cool in desiccators to balance temperature and weigh. Repeat cycle of drying or igniting, cooling, desiccating, and weighing until a constant weight is whichever obtained or until weight change is less than 4% of the previous weighing or 0.5 mg, is less. Store in desiccators until needed.
b. Selection of filter and sample sizes : Choose sample volume to yield between 2.5 and 20 mg dried residue. If volume filtered fails to meet minimum yield, increase sample volume up to 1 L. If complete filtration takes more than 10 min, increase filter diameter or decrease sample volume.
c. Sample analysis : Assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of reagent grade water to seat it. Stir sample with a magnetic stirrer at a speed to shear larger particles, Dry or at least 1 hat 103 to 105°C in an oven cool in a desiccator 37 Central Laboratory, MP Pollution Control Board, Bhopal to balance temperature and weigh. Repeat the cycle of drying cooling desiccating and weighing until a constant weight is obtained.

Calculation

(A- B) x 1000 mg total suspended solids/L= Sample volume ml Where: A = weight of filter + dried residue, mg, and

B = weight of filter mg.



Test 6: Sop For Bod

Principal

The biochemical oxygen demand (BOD test is based on mainly bio-assay procedure which measures the dissolved oxygen consumed by micro- organisms while assimilating and oxidizing the organic matter under aerobic conditions.The standard test condition includes incubating the sample in an air tight bottle, in dark at a specified temperature for specific time.

Apparatus

Sampling and sample preservation shall be done

- Incubation Bottles

300 ml capacity narrow neck special BOD bottles with planed mouth with ground glass stoppers. New bottles should be cleaned with 5 N hydrochloric acid or sulphuric acid followed by rinsing with distilled water. In normal use, bottles once used for Winklers procedure should only be rinsed with tap water followed by distilled water. During incubation (if incubator is used) to ensure proper sealing, time to time, add water to the flared mouth of the bottle.

- Water Bath or Air Incubator 4. Reagents Air incubation with thermostatically controlled 27°C + 1°C Avoid light to prevent possibility of photosynthetic production of oxygen.

Note:- Thermostatically controlled at 27°C+1°C water bath with continuous stirring may be preferred.

Reagents

- Phosphate Buffer Solution

Dissolve 8.5g potassium dihydrogen phosphate (KH2PO4), 21.75g potassium hydrogen phosphate (K3HPO4), 33.4g disodium hydrogen phosphate (Na□HPO4.7H□O) and 1.7g ammonium chloride (NH4Cl) in about 500 ml distrilled water and dilute to 1 litre pH of the solution should be around 7.2 without any further adjustment.

- Magnesium Sulphate Solution

Dissolve 22.5g magnesium sulphate (MgSO4. 7H2O) in distilled water and dilute to 1 litre.

- Calcium Chloride Solution

Dissolve 27.5g calcium chloride in distilled water and dilute to 1 litre.

- Ferric Chloride Solution

Dissolve 0.25g hydrated ferric chloride (FeCl3. 6H2O) in distilled water and dilute to 1 litre.

- Acid and Alkali Solution

1 N sodium hydroxide and 1 N sulphuric acid for neutralization of samples.

Note: - Any of the above solutions showing any sign of biological growth may discarded. be

- Glucose- Glutamic Acid Solution 42 و Central Laboratory, MP Pollution Control Board, Bhopal Dry reagent grade glucose and reagent grade glutamic acid at 103°C for 1 hour. Add 150 mg of glucose and 150 mg of glutamic acid to distilled water and dilute to 1 litre. Prepare fresh immediately before use.

Other Reagents for Dissolved Oxygen Measurement

- Manganous Sulphate Solution

Dissolve manganese sulphate (480g of MnSO4 4H2O or 400g of MnSO4. 2H2O or 364g of MnSO4. H2O) in freshly boiled and cooled water, filter and make up to 1 000 ml. The solutin should not give blue color by addition of acidified potassium iodide solution and starch.

- Alkaline Iodide Solution

Dissolve 500g of sodium hydroxide (or 700g of potassium hydroxide) and 135g of sodium iodide (or 150g or potassium iodide) in freshly boiled and cooled water and dilute to 1 litre.

- Sulphuric Acid Concentrated

- Starch Indicator

Dissolve 2g of starch and 0.2g of salicylic acid as preservative, in 100 ml of hot distilled water.

- Sodium Thiosulphate Stock Solution

Dissolve approximately 25g of sodium thiosulphate (Na2S□O3. 5H□O) in boiled distilled water and make up to 1 000 ml. Add 1g of sodium hydroxide to preserve it.

Procedure

Dissolve 250ml of stock solution (7.7.5) in boiled distilled water and make up to 1 litre and standardize sodium thiosulphate against known standard before use.

a. Preparation of Dilution

Water Aerate the required volume of distilled water in a container by bubbling compressed air for 8 to 12 hours to attain dissolved oxygen saturation. Let it stabilize for 4 h at room temperature (around 27°C). At the time of use add 1 ml each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride for each litre of dilution water. Add 2 to 5 ml of treated sewage per litre of dilution water for seeding purpose. Note: Seeding is not required for domestic sewage or surface water samples.

b. Dilution of Sample and Incubation –Neutralization Procedure

Neutralize the sample to pH around 7.0 using alkali or acid of such
strength that the quantity of reagent does not dilute the sample by more than 0.5 percent.

- Sample Volume and Dilution Techniques

On the basis of chemical oxygen demand (COD), determine expected BOD Use the following formula for calculating sample volume :

Sample volume in ml, X per litre dilution = -x 1000 expected BOD For keeping 2 dilutions take X = 2.5 and 4.0 for single dilution take

X = 3.0 or 3.5 Round off to nearest convenient volume fraction. 43

- In case the of final high dilution. BOD samples, prepare primary dilutions with distilled water and then Take requisite quantity of sample in one litre volumetric flask. Dilute to the mark with bottles the with dilution water by siphoning from the container (5.1). Mix well. Rinse three BOD the diluted sample and fillup these bottles with the diluted sample.
- Stopper the bottles immediately after removing the air bubbles. not require Samples of natural surface water bodies like river, lake and marine, generally do low BOD values.
- Seeding and dilution due to naturally available microbiological population and determination may For be such carried samples which are likely to have BOD less than 5 mg/l, BOD
- Determination out as such (100 percent) without any dilution. of Initial Dissolved Oxygen (DO) Determine days. Prepare initial DO for one bottle and keep two bottles for incubatin at 27°C+1°C for 3 Determine initial six DO blanks by siphoning out dilution water directly into the bottles. in two bottles and incubate remaining for bottles at 27°C+1°C for 3 days.
- Determination of Final DO

Note :- DO After 3 days incubation at 27°C+1°C determine final DO in incubated bottles. shall be determined as per IS3025 (part 38): 1989

Calculation

- When sample is undiluted BOD, mg/l = DO before incubation - DO after incubation.
- When dilution water is not seeded: D□-D2 BOD, mg/l = x 100 P
- When Dilution water is seeded :

D□ - D2 - (B□-B2) f BOD, mg/l = x 100 P

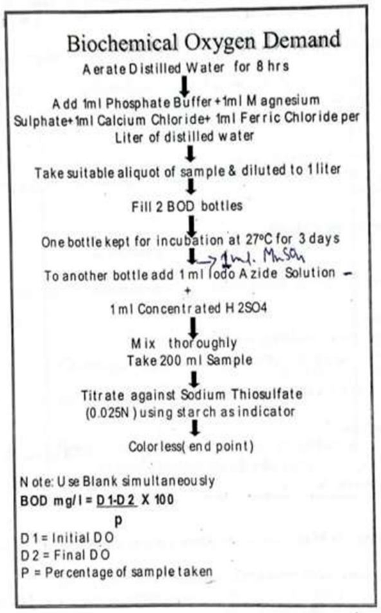
Where D1 = Initial DO of sample in mg/1 D2 = DO of sample after incubation in mg/l

B1 = DO of seed control before incubation in mg/l B2 = DO of seed control after incubation in mg/1

f = ratio of seed in diluted sample to seed to control;

(percent seed in diluted sample): (percent seed in seed control) P = Percentage dilution of sample (sample volume in ml/100)
If the BOD value of the check is outside the range of 200+37 mg/l reject any BOD determinations made with the seed and dilute water and seck the cause of the problem.

Expression of Results
BOD is expressed as mg/1 3 days at 27°C as given in 10 and round off the values as follows:
0 to 10 up to first decimal
Above 10- whole number.



Biochemical Oxygen Demand
Aerate Distilled Water for 8 hrs
↓
Add 1ml Phosphate Buffer+1ml Magnesium Sulphate+1ml Calcium Chloride+ 1ml Ferric Chloride per Liter of distilled water
↓
Take suitable aliquot of sample & diluted to 1 liter
↓
Fill 2 BOD bottles
↓
One bottle kept for incubation at 27°C for 3 days
↓ → 1ml. MnSO4
To another bottle add 1 ml Iodo Azide Solution –
+
1 ml Concentrated H 2SO4
↓
Mix thoroughly
Take 200 ml Sample
↓
Titrate against Sodium Thiosulfate (0.025N) using starch as indicator
↓
Colorless(end point)

Note: Use Blank simultaneously

$$\text{BOD mg/l} = \frac{D1-D2}{p} \times 100$$

D1 = Initial DO
D2 = Final DO
P = Percentage of sample taken

TEST 7: SOP FOR COD OPEN REFLUX METHOD

Principle:
Most types of organic matter are oxidized by a boiling mixture of chromic and sulfuric acids. A sample is refluxed in strongly acid solution with a known excess of potassium dichromate (K2Cr□O,).
After digestion, the remaining unreduced K,Cr□O, is titrated with ferrous ammonium sulfate to determine the amount of K□Cr,O, consumed and the oxidizable matter is calculated in terms of oxygen equivalent.
Keep ratios of reagent weights, volumes, and strengths constant when sample volumes other than 50 mL are used. The standard 2-h reflux time may be reduced if it has been shown that a shorter period yields the same results. Some samples with very low COD or with highly heterogeneous solids content may need to be analyzed in replicate to yield the most reliable data. Results are further enhanced by reacting a maximum quantity of dichromate, provided that some residual dichromate remains.

Detectable range:

COD value > 50 mg O2/L by using procedures

Apparatus
Reflux apparatus, consisting of 500 or 250 mL Erlenmeyer flasks with ground-glass 24/40 neck and 300 mm jacket Liebig. West, or equivalent condenser with 24/40 ground -glass joint, and a hot plate having sufficient power to produce at lest 1.4 W/cm² of heating surface. or equivalent.
Pipets Class A and wide-bore.

Reagents

A . Standard potassium dichromate solution, 0.04167M : Dissolve

12.259g K□Cr:0, primary standard grade, previously dried at 150°C for 2h, in distilled water and dilute to 1000 mL. This reagent undergoes a six-electron reduction reaction; the equivalent concentration is 6x0.04167 M or 0.2500N.

B . Sulfuric acid reagent: Add AgSO, reagent or technical grade crystals or powder, to conc H□SO4 at the rate of 5.5g Ag2SO4/kg H□SO4. Let stand 1 to 2 d to dissolve Mix.

C . Ferroin indicator solution: Dissolve 1.485g 1, 10 phenanthroline monohydrate and 695 mg FeSO4. 7H□O in distilled water and dilute to 100 mL. This indicator solution may be purchased already prepared.

D. Standard ferrous ammonium sulfate (FAS) titrant, approximately 0.25M: Dissolve 98g $Fe(NH,)_2 (SO4)_2$. $6H_2O$ in distilied water. Add 20 mL conc. H_2SO; cool and dilute to 1000 mL. Standardize this solution daily against standard K2Cr-O; solution as follows: Dilute 25.00 mL standard K_2Cr_2O, to about 100 mL. Add 30 mL conc. H_2SO, and cool. Titrate with FAS titrant using 0.10 to 0.15 mL (2 to 3 drops) Ferroin indicator. Molarity of FAS solution Volume 0.04167M K Cr_2O, solution titrated, mL Volume FAS used in titration, mL

E. Mercuric sulfate, HgSO4, crystals or powder. x 0.2500

F. Sulfamic acid: Required only if the interference of nitrites is to be eliminated.

Potassium hydrogen phthalate (KHP) standard, HOOCC,H,COOK: Lightly crush and then dry KHP to constant weight at 110°C. Dissolve 425 mg in distilled water and dilute to 1000 mL.

KHP has a theoretical COD' of 1.176 mg 02/mg and this solution has a theoretical COD of 500 µg Oy/mL. This solution is stable when refrigerated but not indefinitely. Be alert to development of visible biological growth. If practical, prepare and transfer solution under sterile conditions. Weekly preparation usually is satisfactory.

Procedure

Treatment of samples with COD of > 50mg O_2/L : Blend sample if necessary and pipet 50.00 mL into a 500 mL refluxing flask. For samples with a COD of > 900 mg O_2/L use a smaller portion diluted to 50.0 mL.

Add 1g HgSO, several glass beads and very slowly add 5.0 mL sulfuric acid reagent, with mixing to dissolve HgSO4 Cool while mixing to avoid possible loss of volatile materials. Add 25.00 mL 0.04167 M K_2Cr_2O, solution and mix. Attach flask to condenser and turn on cooling water. Add remaining sulfuric acid reagent (70mL) through open end of condenser. Continue swirling and mixing while adding sulfuric acid reagent.

CAUTION: Mix reflux mixture thoroughly before applying heat to prevent local heating of flask bottom and a possible blowout of flask contents.

Cover open end of condenser with a small beaker to prevent foreign material from entering refluxing mixture and reflux for 2h.

Cool and wash down condenser with distilled water. Disconnect reflux condenser and dilute mixture to about twice its volume with distilled water. Cool to room temperature and titrate excess K_2Cr_2O, with FAS using 0.10 to 0.15 mL (2 to 3 drops) ferroin indicator. Although the quantity of ferroin indicator is not critical, use the same volume for all titrations. Take as the end point of the titration the fist sharp color change from blue-green to reddish brown that persists for 1 min or longer. Duplicate determinations should agree within 5% of their average. Samples with suspended selids or components that are slow to oxidize may require additional determinations. The blue-green may reappear. In the same manner reflux and titrate and blank containing the reagents and a volume of distilled water equal to that of sample.

Determination of standard solution: Evaluate the technique and quality of reagents by conducting the test on a standard potas um hydrogen phthalate solution.

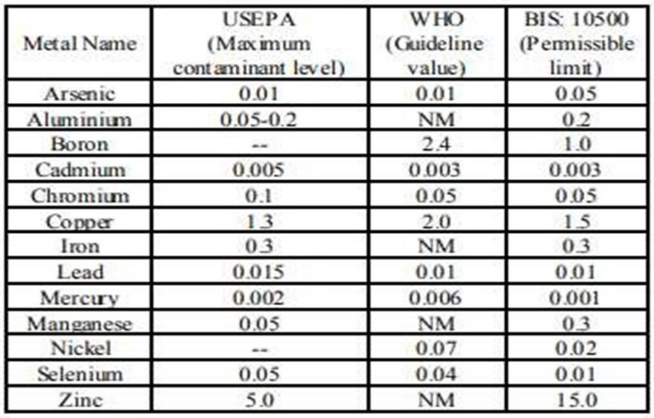
(A-B)x M x 8:00 COD as mg O_2/L = mL sample Where: A = mL FAS used for blank. B = mL FAS used for sample M = molarity of FAS, and 8000 = milliequivalent weight of oxygen x 1000 mL/L. Precision and Bias A set of synthetic samples containmg potassium hydrogen phthalate and NaCl was tested by 74 laboratories At a COD of 200 mgLin the absence of chloride, the standard deviation mg/L (coefficient of variation, 6.5%).

At COD of 160 mg O,/L and 100 mg CI/L, the was +14 mg/L (coefficient of variation, 10.8%)

TEST 8 :Atomic Absorption Spectroscopy (AAS)

Atomic Absorption Spectrophotometer analytical instrument is based on the principle of atomic absorption spectroscopy and is very useful to detect the metal ion concentration present in drinking water samples. When a sample solution is aspirated into a flame then sample element is changed into atomic vapour of that element. Flame contains atoms of element. Furthermore, some atoms are thermally excited by flame whereas most of them remain in ground state. The ground state atoms then absorb the radiation of specific wavelength produced by source i.e. hollow cathode lamp of that specific metal. Now, the wavelength of radiation given off by the source or lamp is similar as that of absorbed by the atoms in the flame.

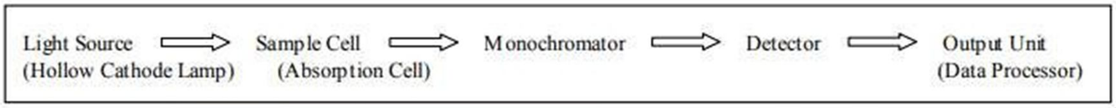
Table 1. A comparison of USEPA, WHO and BIS guideline values (mg/L) of metal ions for drinking water[1, 2, 4]



Metal Name	USEPA (Maximum contaminant level)	WHO (Guideline value)	BIS: 10500 (Permissible limit)
Arsenic	0.01	0.01	0.05
Aluminium	0.05-0.2	NM	0.2
Boron	--	2.4	1.0
Cadmium	0.005	0.003	0.003
Chromium	0.1	0.05	0.05
Copper	1.3	2.0	1.5
Iron	0.3	NM	0.3
Lead	0.015	0.01	0.01
Mercury	0.002	0.006	0.001
Manganese	0.05	NM	0.3
Nickel	--	0.07	0.02
Selenium	0.05	0.04	0.01
Zinc	5.0	NM	15.0

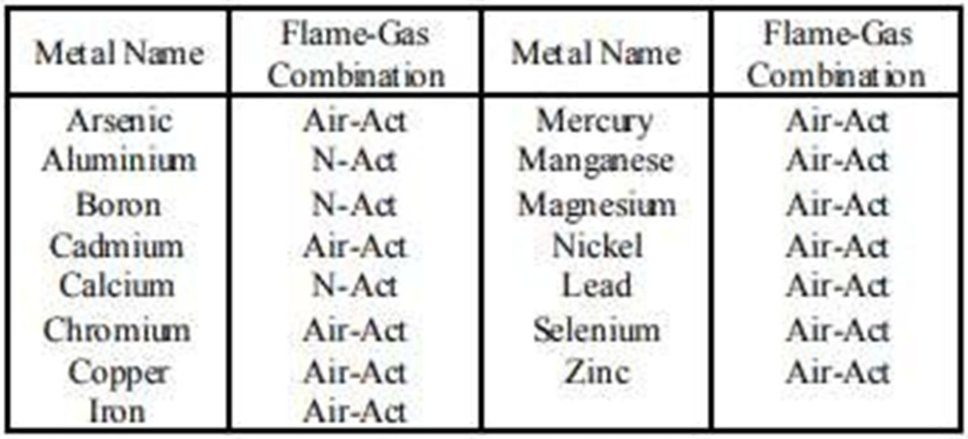
NM: not mentioned

Each atomic absorption spectrophotometer possesses a light source i.e. lamp, sample cell, monochromator, detector and output device. The schematic diagram of an atomic absorption spectrophotometer.



The most common type of burner is a premix, which introduces the spray into a condensing chamber for removal of larger depletes. An online-AAS instrument in the laboratory is shown in figure 2. Important sections of an AAS instrument are described as:

Table 2. Flame-gas combination for metal ion analysis by AAS



Metal Name	Flame-Gas Combination	Metal Name	Flame-Gas Combination
Arsenic	Air-Act	Mercury	Air-Act
Aluminium	N-Act	Manganese	Air-Act
Boron	N-Act	Magnesium	Air-Act
Cadmium	Air-Act	Nickel	Air-Act
Calcium	N-Act	Lead	Air-Act
Chromium	Air-Act	Selenium	Air-Act
Copper	Air-Act	Zinc	Air-Act
Iron	Air-Act		

Air-Act = air-acetylene; N-Act = nitrous oxide-acetylene

a. Light Source (Lamps) Use either a hollow-cathode lamp or electrode less discharge lamp (EDL) for a particular element being measured. Moreover, multi-element hollow-cathode lamps generally provide lower sensitivity than single element lamps whereas EDLs take a longer time to warm up and stabilize.
b. Out Put Unit (Readout) Most of the instruments are equipped with either a digital or null meter readout mechanis m. Generally, the modern instruments are with a microprocessor capable of integrating absorption signals over at high concentrations.
c. Pressure Controlling Valve Generally, a separate reducing value should be used for each gas. Suitable reducing valves maintain the supplies of fuel and oxidant at pressure somewhat higher than the controlled operating pressure of the instrument.
d. Exhaust (Vent) Fix a vent about 6-12 inches above the burner to remove the fumes and vapours from the flame. This practice protects laboratory personnel from vapours, protects the instrument from corrosive vapours, and prevents flame stability from being affected by room drafts. Besides, in laboratory sites with heavy particulate air pollution, prefer the clean laboratory facilities.

Water Sampling and Sample Preservation

Selection of appropriate sample container is also utmost important to minimize the leaching of contaminants from plastic containers into samples and/or absorption of some sample analytes into the walls of plastic containers.

Normally, plastic or glass may be preferred for one material but may be restricted for other. For example, boron, silica and sodium may be leached from soft glass but not plastic. Similarly, trace levels of other metals may be absorbed onto the walls of glass containers. For metal ions, sample containers should be made of high density polyethylene to avoid contamination with metal ions through glass container. But for mercury ion analysis, the samples should be stored in glass container as it reacts with organic materials. Before use, sampling bottles should be rinsed first with tap water, secondly with deionised or ion exchange water and then with nitric acid[2, 10, 12].

A suitable sampling can be performed by using some sampling tools. Manual sampling tools include bacon bombs, dippers, weighted bottles and hand operated pumps. Generally, mechanical, electrical and pneumatic samplers are accessible. Special care should be taken in the selection of the proper instrument for sampling based on the knowledge of the nature of the water being sampled as well as operating conditions. The sampling work should be undertaken according to specified procedures[2, 10]. The samples can be of two types i.e. grab or composite.

Grab samples
Composite samples

Grab samples are single samples which are collected at a specific spot of a site over a short period of time. Therefore, these samples symbolize only the composition of its source at the time and place of collection.

Composite samples are collected by taking an appropriate number of grab samples obtained at equal intervals or proportional to flow. Flow proportional composite samples are collected when the flow properties are continually changing.

After the completion of sampling task, preservation of the collected water samples is necessary to obtain good results. Therefore, sample preservation can be achieved by making slurry of ice and water for cooling at 4°C to minimize the potential for volatilization or biodegradation between sampling and analysis.

Some metal ions like aluminium, cadmium, chromium, copper, iron, lead, manganese, silver and zinc are subject to loss by adsorption on, or ion exchange with the walls of glass containers. Therefore, ultra pure nitric acid is necessary to add into the sample for metal ions preservation. Besides this, acidification of the collected water sample is essential below pH 2.0 to minimize the precipitation and adsorption on container walls.

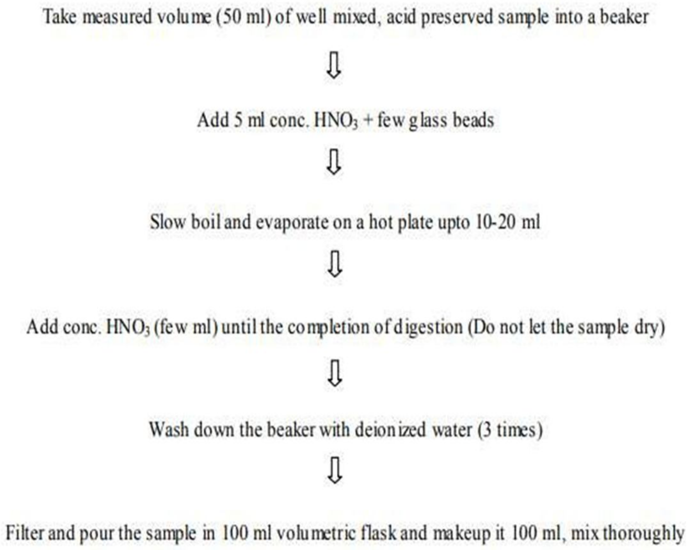
Sample Preparation

Sample preparation is a very important step in analytical chemistry. Therefore, samples should be prepared very carefully without any mistake or carelessness. The samples for metal ion analysis in drinking water samples by atomic absorption spectrophotometer can be prepared by adopting the standard method.

Preparation of Standard Solution, Standardization, Data Analysis and Calculation Standard solutions of metal ions are necessary to standardize and calibrate the instrument.

Moreover, the preparation of standards is also an important and crucial part of analysis and it requires much attention of any student or researcher for better results. Therefore, the preparation of standard solution of various metals, standardization, data analysis and calculation can be performed.

Scheme 1:



Take measured volume (50 ml) of well mixed, acid preserved sample into a beaker

Add 5 ml conc. HNO_3 + few glass beads

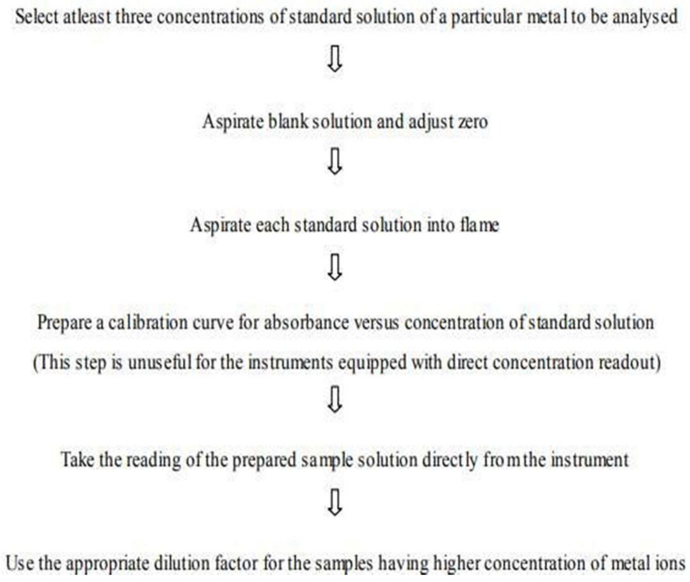
Slow boil and evaporate on a hot plate upto 10-20 ml

Add conc. HNO_3 (few ml) until the completion of digestion (Do not let the sample dry)

Wash down the beaker with deionized water (3 times)

Filter and pour the sample in 100 ml volumetric flask and makeup it 100 ml, mix thoroughly

Scheme 2:



Select atleast three concentrations of standard solution of a particular metal to be analysed

Aspirate blank solution and adjust zero

Aspirate each standard solution into flame

Prepare a calibration curve for absorbance versus concentration of standard solution
(This step is unuseful for the instruments equipped with direct concentration readout)

Take the reading of the prepared sample solution directly from the instrument

Use the appropriate dilution factor for the samples having higher concentration of metal ions

Conclusions

Atomic absorption spectroscopy has become a method of choice of students and researchers in analytical chemistry due to its wide applicability. The technique is useful not only for metal ion analysis in several matrices like water, soil, sediments, food materials but also for the speciation of metal ions in these matrices.

Moreover, hyphenated AAS method has emerged as an essential tool for analytical job. The present article will be helpful for undergraduate, postgraduate and even researchers who possess an interest in laboratory experiments related with analytical chemistry as well as with environmental sciences.

V. OBSERVATION *AND CALCULATION*

A. Chemical Tests

Sr	Parameter	Unit	Test Method	Range of Testing	Result
1	pH	pH Units	4500-H+B APHA std. methods 23 rd Edn.	0.5-13.5	7.8
2	Colour	Pt.Co.Scale	(2120-B, APHA Std. Methods, 23rd Edn.)	2-99 Co.Pt. Unit	Reddish Yellow
3	Total Solids	mg/l	(2540 B, APHA std. methods 23rd Edn.)	10-100000mg/l	820.0
4	Total Dissolved Solids	mg/l	(2540 B, APHA std. methods 23rd Edn.)	10-10000mg/l	684
5	Suspended Solids	mg/l	(2540 B, APHA std. methods 23rd Edn.)	5-10000mg/l	136
6	Chloride	mg/l	4500-Cl- B, APHA Std. Methods, 23rd Edn.	5-100mg/l	56
7	Chemical Oxygen Demand	mg/l	(5220 B, APHA Std. Methods, 23rd Edn.)	5.0-10000 mg/l	180
8	B.O.D (3 Days 27oC)	mg/l	IS 3025,1993	1-10000 mg/l	42

The result of physicochemical analysis is presented in **Table**. The pH value indicated extremely acidic nature of effluent due to presence of acids originated primarily from the cleaning units of the industry. The high conductivity value suggested the occurrence of large amount of inorganic compounds in the effluent. The elevated value of turbidity also indicated the presence of sizable amount of suspended solids derived from washing and bathing units of the industry.

B. General Characteristics

Table : 1: Sample: **ETP Sludge**

S.No.	Name Of Tests	Result(%)
01.	Chromium	0.0035
02.	Iron	11.48
03.	Lead	0.0029
04.	Zinc	0.0077
05.	Aluminium	0.137

Sample From :- K.E.C. International Ltd. Jabalpur

Date Of Collection :- 11/03/2025

Date Ofanalysis :- 11/03/2025

S.No.	Parameters	Unit	Sample Details		
			ETP Outlet	Leachate Water	Borewell Water
1	Colour	-	Reddish Yellow	Greyish	Colourless
2	Ph	-	7.25	7.34	6.98
3	Chloride	Mg/L	36	130	22
4	Total Solids	Mg/L	360	792	232
5	Dissolved Solids	Mg/L	290	680	198
6	Suspended Solids	Mg/L	70	112	34
7	BOD	Mg/L	32	56	-
8	COD	Mg/L	150	240	-
9	Lead (Pb)	Mg/L	-	0.342	BDL
10	Total Chromium (Cr)	Mg/L	-	0.182	BDL
11	Copper (Cu)	Mg/L	-	3.042	BDL
12	Zinc (Zn)	Mg/L	6.125	BDL	BDL
13	Iron (Fe)	Mg/L	2.129	-	0.128
14	Nickel (Ni)	Mg/L	-	0.024	BDL
15	Arsenic (As)	Mg/L	0.012	BDL	BDL
16	Mercury (Hg)	Mg/L	0.024	BDL	BDL

VI. RESULTS

1) The benefits and applications of this approach are demonstrated by a case study presented in this paper. It was found that the number of samples and cost of sample analysis can be greatly reduced by the use of systematic instead of random sampling

2) Observation & Results are compared with CPCB Guidelines of Inorganic Chemical Industry- Galvansing Plant

The values of following Parameter are well described below-

S.NO.	Parameter	Observed value	Limits As Per CPCB Guidelines	Remark
01.	pH	7.25	5.5-9	In the Range
02.	Chlroide	130	250	Below the Limit
03.	Total Solids	360	500	Below the Limit
04.	Dissolved Solids	290	500	Below the Limit
05.	Suspended Solids	150	100	More than the Limit
06.	BOD	32	30	Approx. Equal

07.	COD	350	250	More than the Limit
08.	Lead(Pb)	0.342	0.1	More than the Limit
09.	Zinc(Zn)	6.125	5	More than the Limit
10	Iron(Fe)	2.129	3	Below the Limit
11.	Nickel(Ni)	0.024	3	Below the Limit
12.	Arsenic(As)	0.012	0.2	Below the Limit
13.	Mercury(Hg)	0.024	0.01	Below the Limit
14.	Copper(Cu)	3.042	3	Almost Equal
15.	Chromium(Cr)	0.182	2	Below the Limit

3) Whereas pH,BOD, Copper Parameter result are almost equal with the prescribed limit as per CPCB Guidelines.
4) After Observation, Suspended Solids, COD, Lead, Zinc are crossing the prescribed limit of CPCB Guidelines.

VII. CONCLUSION

The success or failure of any monitoring scheme depends, to a large extent, on the design of the sampling programme. Although there a vast literature on chemical analysis of wastewater, and adequate information about sampling techniques.

The analysis of effluent recorded high load of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The BOD load was associated with the presence of organic materials perhaps in the form of organic waste and the COD load was linked with the oxidisable chemicals in the effluent The analysis further revealed large amount of iron and zinc and marginal amount of lead and chromium. All these metallic substances originated from the raw materials ,bathing and washing units of the industry. The presence of different metals contributed to the toxicity of the galvanizing industry effluent and to the living organism also.

From the above findings it can be concluded that the galvanizing industry effluent is toxic in nature, capable of altering the quality of receiving ecosystem and harmful to the living organisms both plants and animals. The effluent requires appropriate treatment to reduce its toxicity to a minimum level before releasing into nearby areas.

A. ETP Solid Waste (Sludge)

1) It is in the form of cake, which is formed after de-watering of treated slurry. It can either be formed at the outlet of the filter press or in the drying beds. From the filter press, cake is formed on a uniform basis and is collected in trolleys kept at the bottom of the filter press discharge chute.
2) Sludge is shifted to off-site disposal facilities developed within plant premises through trolleys. These trolleys are decanted, and sludge is disposed of into the facilities, which have been constructed as per the MOEF guidelines and as per the approved design from the M.P. Pollution Control Board. ETP sludge generation is about 15.53 tons/month, which varies as per the quantity of acid and acidic water discarded by the galvanizing plant.
3) Dried form of Effluent is stored in concrete tank constructed at the Ground Level. Mainly in Rainy Season, leachate may take place resulting in pollution of Groundwater.

VIII. SUGGESTIONS & FUTURE SCOPE

Effect of Parameter and suggestions to control is mentioned below-

1) To lower the impact of colour from Fe,Cr, imperable layer is provided below the concrete tank.
2) For Total solids crossing the prescribed limit, not much effect is showed. Only Quantity is increased and handling and storage become difficult.
3) For Dissolved Solids, no much effect. Only volume is enhanced.
4) For Suspended Solids crossing the limit as per CPCB, Sedimentation time in ETP Plant should be increased so that more settlement take place. Also, the size of the tank can be altered.
5) For Chemical Oxygen Demand, Aeration must be given preferably Floating type or Cascade type Aerator should be installed.So, that the wate becomes almost semi-solid.
6) To lower the value of Metals,

A. *Absorption: Use of Activated Charcoal*

- Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) are persistent environmental pollutants with toxic effects on humans and ecosystems.
- Activated carbon (AC) is widely used due to its high surface area, porosity, and surface functionality, making it an effective adsorbent for heavy metals.
- However, natural organic matter (NOM) present in water can influence the adsorption process.
- Regeneration of spent activated carbon is crucial for cost- effectiveness and sustainability.

B. *Mechanism of Heavy Metal Adsorption*

- Adsorption occurs via:
  - Physical adsorption (Van der Waals forces),
  - Chemical adsorption (complexation, ion exchange),
  - Electrostatic attraction (between metal cations and negatively charged surface groups).
- Surface functional groups like hydroxyl (-OH), carboxyl (-COOH), and carbonyl (-C=O) are important in binding metal ions.
- Activated carbon is an effective material for heavy metal adsorption, but performance is influenced by NOM in natural waters.
- Regeneration is critical to maintain sustainability and reduce operational costs.
- The choice of regeneration method depends on the type of pollutant, economic considerations, and environmental impact.

C. *Reverse Osmosis:*

Principle of Reverse Osmosis

- RO uses a semi-permeable membrane that allows water molecules to pass while rejecting most dissolved salts, organics, and metal ions.
- A pressure greater than the osmotic pressure of the solution is applied to force water through the membrane, leaving contaminants behind.

Above process are costly, hence less preffered by the industry in real time.

For ETP Sludge as leachate, it is recommended to construct concrete tank with waterproof imperable layer before putting the waste in tank.

At last only purpose to make the sludge waste more solidify which helps in easy to handling and dumping.

D. *Emerging Technologies for Enhanced Disinfection*

New technologies are making wastewater treatment more effective and efficient. Advanced oxidation processes use powerful oxidants to destroy contaminants. Nanotechnology creates materials that can trap or break down pollutants.

Membrane bioreactors combine biological treatment with membrane filtration. They produce very clean water and take up less space than traditional systems.

Electrochemical disinfection uses electricity to generate disinfectants directly in the water. It’s effective against a wide range of pathogens and doesn’t require chemical storage.

These new technologies often cost more upfront. But they can save money in the long run through improved efficiency and water quality.

E. *Recycling and Reuse Strategies*

Recycling and reuse strategies play a crucial role in industrial wastewater treatment. These approaches help reduce water consumption, minimize environmental impact, and create cost-effective solutions for businesses.

F. *Reducing Water Footprint with Recycling Systems*

- Industrial wastewater recycling systems can greatly reduce a company’s water footprint. These systems treat and purify wastewater, making it suitable for reuse in various processes.
- Membrane filtration is a popular recycling method. It removes contaminants and allows water to be reused multiple times. This technique can save up to 90% of water in some industries.

- Another effective approach is reverse osmosis. It removes dissolved solids and impurities, producing high-quality water for reuse. Many factories use this method to recycle cooling water and process water.
- Biological treatment systems also play a key role. They use microorganisms to break down organic pollutants, creating cleaner water for reuse in landscaping or non-potable applications.

G. Innovative Reuse Solutions for Industrial Applications

- Industries are finding creative ways to reuse treated wastewater. Some companies use it for cooling towers, boilers, and equipment cleaning.
- In agriculture, treated wastewater irrigates crops and waters livestock. This practice conserves freshwater resources and provides nutrients to plants
- The construction industry reuses treated wastewater for dust control and concrete mixing. This approach saves large amounts of potable water.
- Some innovative firms extract valuable materials from wastewater. They recover metals, minerals, and chemicals for resale or reuse in manufacturing processes.

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