

INTEGRATED URBAN WATER REMEDIATION-DEVELOPING A SUSTAINABLE SOLUTION FOR CONTAMINATED WATER

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Civil Engineering

By

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with Grade "A++" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL – 2024



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Lingeshwaran R (Register no: 40200006) Hariharan M (Register no:40200019) who carried out the project entitled **"Integrated Urban Water Remediation-Developing a Sustainable solution for Contaminated water "**under our supervision from October 2023 to April 2024


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We Lingeshwaran R (Register No: 40200006), Hariharan M (Register No: 40200019), here by declare that the Project Report entitled "Integrated Urban Water Remediation-Developing A Sustainable Solution for Contaminated Water" done by us under the guidance of Dr. B. PRIYADHARSHINI, M.E., Ph.D., is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

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ABSTRACT

Integrated urban water remediation is imperative for addressing the escalating challenges posed by water pollution in urban areas. This study presents a comprehensive approach to remediate contaminated water, with a particular emphasis on the removal of heavy metal contaminants such as lead and chromium from tannery industry effluent, utilizing water hyacinth (*Eichhornia crassipes*) as a phytoremediation agent. The project commenced with the selection of a textile industry study area, followed by the systematic collection and analysis of groundwater samples to identify contaminants. Water hyacinth was chosen as the primary phytoremediation species due to its remarkable ability to absorb and accumulate heavy metals. In this research investigates the efficacy of phytoremediation using water hyacinth (*Eichhornia crassipes*) for reducing lead (Pb) and chromium (Cr) content in wastewater Through rigorous experimentation, it was established that the application of water hyacinth resulted in a significant reduction of lead by 45% and chromium by 22%. Upon plantation in the effluent, observations revealed a reduction in plant size by 20cm, prompting an in-depth analysis of factors influencing water hyacinth health and performance. The findings of this study underscore the significance of integrated approaches in urban water management, particularly in industrial settings such as tanneries. By leveraging the remarkable capabilities of water hyacinth in phytoremediation, this research contributes to mitigating water pollution and safeguarding environmental and public health in urban areas.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	iv
	LIST OF FIGURES	vii
	LIST OF TABLES	ix
1	INTRODUCTION	
	1.1 GENERAL	1
	1.2 WATER CONTAMINATION	2
	1.3 TYPES OF CONTAMINANTS IN CITY WATER	3
	1.4 EFFECTS OF WATER POLLUTION	7
	1.5 PHYTOREMEDIATION METHOD	13
	1.6 PLANTS USED IN PHYTOREMEDIATION	14
2	LITERATURE SURVEY	
	2.1 GENERAL	17
	2.2 REVIEW OF THE LITERATURE	17
	2.3 INFERENCE FROM THE LITERATURE	18
	2.4 AIM OF THE STUDY	19
	2.5 OBJECTIVE OF THE STUDY	19
3	METHOD OF INVESTIGATION	
	3.1 FLOW CHART OF METHODOLOGY	21
	3.2 STUDY AREA	22
	3.3 TANNERY INDUSTRY EFFLUENT	23
	3.4 PROCESS DESCRIPTION IN TANNERY INDUSTRY	23

3.5	AQUATIC PLANT	25
3.6	SAMPLE COLLECTION	27
3.7	EXPERIMENTAL INVESTIGATION	29
3.8	PLANT STUDY	33
4	RESULT AND DISCUSSION	
4.1	EXPERIMENTAL RESULTS – BORE SAMPLES	35
4.2	BATCH RESULTS FOR TANNERY INDUSTRY EFFLUENT (BATCH TEST)	38
4.3	ARTIFICIAL POND RESULTS FOR TANNERY INDUSTRY EFFLUENT (REAL TIME TEST)	46
4.4	OBSERVATION OF THE PLANT	54
5	CONCLUSION	
5.1	SUMMARY	55
5.2	CONCLUSION	56
5.3	FUTURE SCOPE OF STUDY	56
	REFERENCES	

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NO
1.1	ARSENIC EFFECTS ON THE HUMAN BODY	6
1.2	DEATH RATE DUE TO UNSAFE WATER SOURCE	8
1.3	CONSUMPTION OF MICROPLASTICS	9
1.4	POLLUTION RELATED DEATH CHART	10
3.1	METHODOLOGY	21
3.2	STUDY AREA REPRESENTATION	22
3.3	CONTAMINATED WATER FROM TANNERY INDUSTRY	23
3.4	EFFLUENTS IN TANNERY INDUSTRY	24
3.5	PROCESS INVOLVED IN TANNERY INDUSTRY	25
3.6	EICHHORNIA	26
3.7	PROCESS OF COLLECTING SAMPLE	27
3.8	SAMPLING POINTS	28
3.8	TANNERY INDUSTRY SAMPLE	29
3.14	PLANTATION IN EFFLUENT	29
3.15	PLANTATION IN WETLAND POND	30
3.16	TESTING IN LABORATORY	32
3.17	LEAD CHLORIDE POWDER	33
3.18	GROWTH RATE OF PLANT	34
4.1	TDS OF BORE SAMPLE	36

4.2	ELECTRICAL CONDUCTIVITY OF BORE SAMPLE	37
4.3	HARDNESS OF BORE SAMPLE	37
4.4	ALKALINITY OF BORE SAMPLE	38
4.5	TURBIDITY VALUES BEFORE AND AFTER TREATMENT	40
4.6	ELECTRICAL CONDUCTIVITY BEFORE AND AFTER TREATMENT	41
4.7	PH BEFORE AND AFTER TREATMENT	41
4.8	TDS BEFORE AND AFTER TREATMENT	42
4.9	HARDNESS BEFORE AND AFTER TREATMENT	42
4.10	ALKALINITY BEFORE AND AFTER TREATMENT	43
4.11	CHROMIUM CONTENT BEFORE AND AFTER TREATMENT	43
4.12	CALCIUM BEFORE AND AFTER TREATMENT	44
4.13	MAGNESIUM CONTENT BEFORE AND AFTER TREATMENT	44
4.14	NITRATE BEFORE AND AFTER TREATMENT	45
4.15	CHLORIDE BEFORE AND AFTER TREATMENT	45
4.16	SULPHATE BEFORE AND AFTER TREATMENT	46
4.17	EFFLUENT BEFORE TREATMENT	46
4.18	EFFLUENT AFTER TREATMENT	47
4.19	TURBIDITY BEFORE AND AFTER TREATMENT	49

4.20	ELECTRICAL CONDUCTIVITY BEFORE AND AFTER TREATMENT	49
4.21	TDS BEFORE AND AFTER TREATMENT	50
4.22	HARDNESS BEFORE AND AFTER TREATMENT	50
4.23	ALKALINITY BEFORE AND AFTER TREATMENT	51
4.24	CHROMIUM BEFORE AND AFTER TREATMENT	51
4.25	CALCIUM BEFORE AND AFTER TREATMENT	52
4.26	MAGNESIUM CONTENT BEFORE AND AFTER TREATMENT	52
4.27	NITRATE BEFORE AND AFTER TREATMENT	53
4.28	LEAD CHLORIDE BEFORE AND AFTER TREATMENT	53
4.29	SULPHATE BEFORE AND AFTER TREATMENT	54

LIST OF TABLES

TABLE NO	TITLE	PAGE NO
1.1	DEATH BY WATER POLLUTION STATISTICS	12
1.2	TYPES OF PLANT USED IN PHYTOREMEDIATION METHOD	14
3.1	TABLE OF SAMPLES LATITUDE AND LONGITUDE	28
4.1	PHYSICAL PARAMETER OF BORE SAMPLE	35
4.2	PHYSICAL PARAMETER OF TANNERY INDUSTRY EFFLUENT	39
4.3	CHEMICAL PARAMETERS OF TANNERY INDUSTRY EFFLUENT	39
4.4	PHYSICAL PARAMETER OF TANNERY INDUSTRY EFFLUENT IN ARTIFICIAL WETLAND POND	47
4.5	CHEMICAL PARAMETER OF TANNERY INDUSTRY EFFLUENT IN ARTIFICIAL WETLAND POND	49
4.6	OBSERVATION FROM WATER HYACINTH PLANT	54

CHAPTER 1

INTRODUCTION

1.1 GENERAL

India, a land of diversity and contrasts, faces a pressing challenge that transcends its cultural, geographic, and economic boundaries. There is vast and intricate network of water sources in this nation, from the mighty rivers to the smallest ponds, is threatened by a range of contaminants, including industrial effluents, agricultural runoff, and inadequate sanitation practices. These contaminants not only jeopardize the health of millions but also strain the delicate balance of ecosystems that rely on these water bodies. In response to this urgent and complex issue, our project is dedicated to developing sustainable solutions for water contamination in India. With a focus on safeguarding public health, preserving natural ecosystems, and promoting responsible water management, we embark on a mission that embraces innovation, community engagement, and policy advocacy.

Urbanization and industrialization have brought about significant advancements in society, but they have also led to the alarming degradation of natural resources, particularly water bodies. Among the various industries contributing to water pollution, the tannery sector stands out due to its extensive use of chemicals and heavy metals in the leather production process. The discharge of untreated or inadequately treated effluent from tanneries poses serious environmental and public health risks, necessitating urgent remediation measures. Integrated urban water remediation has emerged as a holistic approach to address the complex challenges of water pollution in urban areas. This approach integrates multiple strategies and technologies to restore water quality, mitigate pollution, and promote sustainable water management practices. By combining various remediation techniques, such as physical, chemical, and biological methods, integrated urban water remediation offers a comprehensive solution to tackle diverse sources of contamination.

The primary objective of this project is to assess the efficacy of phytoremediation, particularly utilizing the water hyacinth (*Eichhornia crassipes*) plant, in removing lead and chromium from tannery effluent. Through a combination of field

sampling, laboratory experiments, and performance evaluations, this study aims to demonstrate the feasibility and effectiveness of phytoremediation as a sustainable and cost-effective approach for water remediation in urban industrial settings. By elucidating the mechanisms of heavy metal removal by water hyacinth and evaluating the performance of phytoremediation systems in real-world conditions, this research contributes to the growing body of knowledge on integrated urban water remediation. The findings of this study are expected to inform policymakers, environmental practitioners, and stakeholders about the potential of phytoremediation as a viable solution for addressing water pollution challenges in urban areas.

1.2 WATER CONTAMINATION

Water contamination refers to the presence of harmful substances or pollutants in natural water sources, rendering the water unsafe for its intended use, whether that be for drinking, irrigation, industrial processes, or aquatic ecosystems. Contaminants can encompass a wide range of substances, including chemicals, microorganisms, heavy metals, and even physical agents like sediments.

1.2.1 SOURCES OF CONTAMINATION

i. Industrial Discharges

Factories and manufacturing facilities often release pollutants into nearby water bodies. These pollutants can include chemicals, heavy metals, and toxins, which may disrupt aquatic ecosystems and pose health risks to humans.

ii. Agricultural Runoff

Pesticides, fertilizers, and herbicides applied to crops can be carried into waterways through rainwater runoff. These chemicals can contaminate water sources, affecting both aquatic life and human health.

iii. Municipal Sewage

Wastewater from households and urban areas can contain a variety of contaminants, including pathogens (bacteria, viruses), nutrients

(nitrogen, phosphorus), and organic matter. If not adequately treated, sewage can contaminate rivers, lakes, and groundwater.

iv. Mining Activities

Mining operations release pollutants like heavy metals (e.g., mercury, lead) and acidic drainage, which can leach into water sources, causing long-lasting contamination.

v. Landfills and Hazardous Waste Sites

Improperly managed landfills and hazardous waste disposal sites can lead to the leakage of hazardous chemicals and toxins into the groundwater, contaminating aquifers.

vi. Natural Sources

Some contaminants, such as arsenic or radon, occur naturally in certain geological formations. When these naturally occurring substances leach into groundwater, they can contaminate wells and water sources.

1.3 TYPES OF CONTAMINANTS IN CITY WATER

City water can contain various contaminants, which are substances or microorganisms that can adversely affect water quality and safety. These contaminants can arise from natural sources, industrial activities, pollution, and aging infrastructure. The types of contaminants in city water can vary depending on the source of the water, the treatment processes applied, and local environmental conditions. Here are some common categories of contaminants found in city water.

1. Microbial Contaminants
2. Chemical Contaminants
3. Physical Contaminants
4. Inorganic Contaminants
5. Radionuclides
6. Other Contaminant

1.3.1 MICROBIAL CONTAMINANTS

- i. *Bacteria*: Bacterial contaminants like *Escherichia coli* (*E. coli*) and coliform bacteria can enter water supplies through sewage or animal waste runoff. These bacteria can indicate fecal contamination and potentially cause gastrointestinal illnesses if consumed.
- ii. *Viruses*: Waterborne viruses, such as norovirus and hepatitis A, can originate from human and animal waste. Ingesting water contaminated with viruses can lead to waterborne diseases that affect the digestive and respiratory systems.
- iii. *Protozoa and Parasites*: Microscopic organisms like *Giardia* and *Cryptosporidium* are resistant to chlorine disinfection and can cause diseases like giardiasis and cryptosporidiosis. They may contaminate water from various sources, including agricultural runoff.

1.3.2 CHEMICAL CONTAMINANTS

- i. *Disinfection Byproducts (DBPs)*: When chlorine or other disinfectants react with naturally occurring organic matter in water, they can produce DBPs like trihalomethanes and halo acetic acids. Long-term exposure to these byproducts may increase the risk of cancer and other health issues.
- ii. *Heavy Metals*: Heavy metals like lead, arsenic, mercury, and cadmium can leach into water from natural sources, industrial discharges, and aging plumbing systems. These contaminants pose various health risks, from developmental issues in children (lead) to neurological and cardiovascular problems (mercury).
- iii. *Chemical Pollutants*: Industrial chemicals, pesticides, herbicides, and solvents can enter water supplies through runoff, spills, and improper disposal. They can have a wide range of health effects depending on the *specific chemical involved*.

- iv. *Pharmaceuticals and Personal Care Products (PPCPs)*: Residues of drugs (e.g., antibiotics, hormones) and personal care products (e.g., cosmetics, fragrances) can be found in water due to incomplete removal during treatment. The long-term health effects of exposure to low levels of PPCPs are still being studied.
- v. *Volatile Organic Compounds (VOCs)*: VOCs like benzene, toluene, and trichloroethylene can contaminate water from industrial activities, leaking underground storage tanks, or hazardous waste sites. Prolonged exposure to some VOCs can lead to health problems.

1.3.3 INORGANIC CONTAMINANTS

- I. *Arsenic*: As many as 140 million people worldwide are exposed to arsenic levels in drinking water that are higher than the World Health Organization's (WHO) provisional guideline of 10 µg/L. The International Agency for Research on Cancer has identified arsenic exposure as a significant factor contributing to the development of lung, bladder, skin, and kidney cancers.
- II. *Nitrate and Nitrite*: Elevated levels of nitrate and nitrite in water can result from agricultural runoff and septic systems. In infants, high nitrate levels can lead to a condition called methemoglobinemia, or "blue baby syndrome".
- III. *Fluoride*: While added to many municipal water supplies to prevent tooth decay, excessive fluoride levels can cause dental fluorosis or other health concerns, such as skeletal fluorosis.
- IV. *Sulfate*: High sulfate levels in water can occur naturally in certain geological formations and may lead to a laxative effect in some individuals.
- V. *Chloride*: Elevated levels can indicate pollution from road salt and industrial sources.

- VI. *Lead and Copper*: These can leach from pipes, especially in older plumbing systems, and pose health risks.

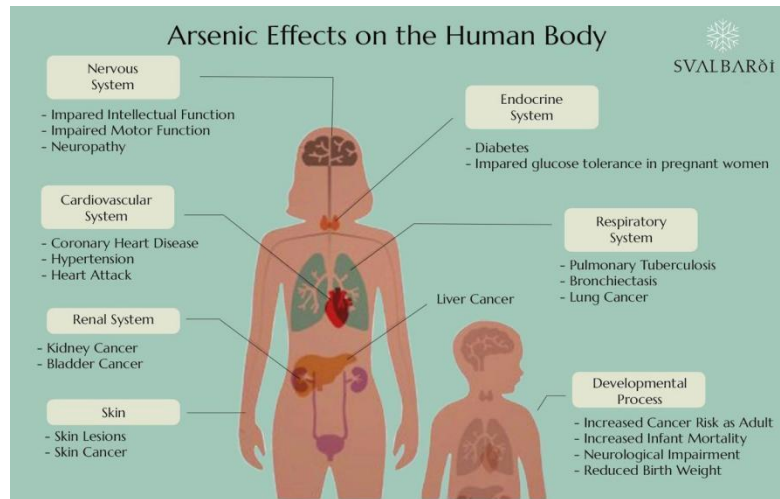


Fig 1.1 Arsenic Effects on The Human Body

1.3.4 RADIONUCLIDES

- i. *Radon*: Radon gas can dissolve in groundwater and be found in city water supplies. Radon exposure through drinking water may contribute to indoor radon exposure when water is used for showers and cooking.
- ii. *Uranium*: Elevated uranium levels may occur naturally in groundwater and pose health risks if consumed regularly.

1.3.5 PHYSICAL CONTAMINANTS

Sediments:

Particles of soil, sand, and debris can enter the water supply due to soil erosion, construction activities, and aging infrastructure. Excessive sediment can affect water clarity and taste. City water treatment plants employ various processes to remove or reduce these contaminants, ensuring the delivery of safe and clean drinking water to residents. Regular water quality monitoring and adherence to regulatory standards are essential for maintaining water safety.

1.4 EFFECTS OF WATER POLLUTION

Water pollution has far-reaching and often detrimental effects on the environment, public health, and economies. These effects can vary depending on the type and severity of pollution, the affected water bodies, and the duration of exposure. Here is an elaborate explanation of the effects of water pollution. When pollutants like pesticides, fertilizers, waste, and septic system effluents infiltrate an aquifer, they render water unfit for human consumption. Water contamination poses various risks to human health, manifesting through three primary pathways.

- I. Drinking water polluted by sewage
- II. Consuming water that contains chemical contaminants
- III. Consuming microplastics that are in polluted water

Contaminated water infiltrates communities through inadequately treated urban, industrial, and agricultural wastewater, which finds its way into surface water or groundwater. This widespread practice results in the chemical pollution and biological contamination of drinking water sources for millions annually, consequently elevating the incidence of waterborne diseases and associated fatalities. The World Health Organization (WHO) paints a grim picture, reporting that approximately 2.2 billion people use unsafe water yearly which is the cause of some 829,000 preventable deaths. Science Advice for Policy by European Academies (SAPEA) echoes the same concern, warning that if plastic enters the oceans at a faster rate than it is today, it may create future health problems. Water pollution not only imposes a significant health burden on society but an economic and social one as well. Water pollution contributes to reduced productivity and earnings, as individuals must dedicate considerable time and energy to obtaining safe water. The economic impact extends further through healthcare costs incurred in treating waterborne diseases, posing a substantial financial burden, particularly on developing nations.

1.4.1 DRINKING WATER POLLUTED BY SEWAGE

Developed nations have significantly curtailed sewage pollution through widespread adoption of treatment plants. However, in many developing regions,

inadequate treatment and regulatory oversight still contribute to sewage dumping and water pollution.

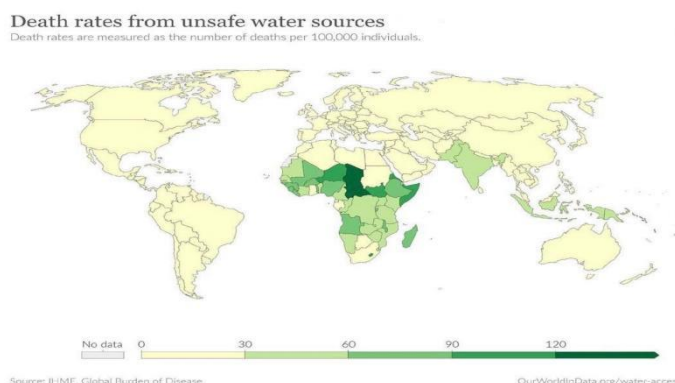


Fig 1.2 Death Rate Due to Unsafe Water Source

In developing countries, inadequate treatment capacity and lax regulatory enforcement allow sewage dumping to persist as a significant issue. Breakdowns in treatment infrastructure due to accidents, conflict, natural disasters, or neglect result in frequent discharge of sewage into water sources. This map from the IHME's Global Burden of Disease survey shows death rates from unsafe water sources which are generally contaminated by sewage. According to the World Health Organization, over 2 billion people globally rely on drinking water sources contaminated with fecal matter. This form of biocontamination is closely associated with acute diarrheal diseases caused by waterborne pathogens such as cholera, *E. coli*, shigella, salmonella, coliforms, giardia, and various viruses. Tragically, an estimated 829 thousand individuals, including 297 thousand children under the age of 5, succumb to diarrhea each year due to consuming sewage-contaminated unsafe drinking water.

1.4.2 CONSUMING WATER THAT CONTAINS CHEMICAL CONTAMINANTS

Chemicals including solvents, disinfection byproducts, pesticides, heavy metals, and radionuclides like radium contribute to persistent drinking water pollution. Agricultural runoff laden with pesticides and fertilizers seeps into surface and groundwater, perpetuating contamination. Industrial pollutants and heavy metals also infiltrate water supplies, particularly prevalent in developing nations. The detrimental

health consequences of water pollution, if consumed, present significant risks to public health. Chemical toxins in water are causative factors for cancer, neuroendocrine disruption, cardiovascular, hepatic, and renal problems, as well as various reproductive health issues.

1.4.3 CONSUMING MICROPLASTICS THAT ARE IN POLLUTED WATER

Microplastics, pervasive in nearly all oceans worldwide, including the Arctic, originate from plastic products disposed into rivers, lakes, or the sea, gradually fragmenting into microscopic particles. Additionally, various textiles, cosmetics, and other items washed or flushed down drains release small plastic components. Although research on their impacts is ongoing, microplastics are believed to pose risks to human health and marine ecosystems, potentially contaminating seafood consumed by humans. Per capita consumption estimates of microplastics, researched by Doctors Kannan and Vimalkumar of the New York University School of Medicine, underscore the prevalence of this environmental concern.

Typical Per Capita Consumption of Microplastics

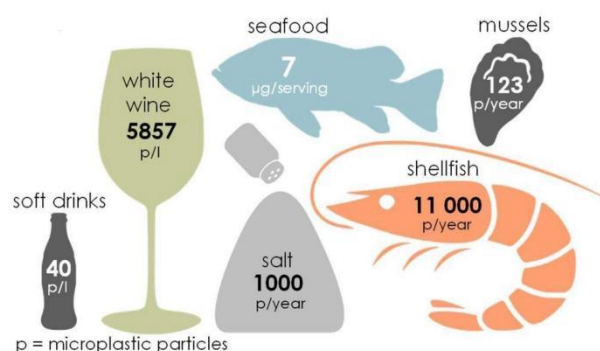


Fig 1.3 Consumption of Microplastics

Chemicals utilized in plastic manufacturing, along with pollutants that adhere to the surface of microplastics over time in seawater, possess toxicity. Exposure to microplastics can occur through ingesting contaminated water or, more commonly, consuming seafood tainted with microplastics. These toxic chemicals have been

associated with the onset of cancer, as well as diverse developmental, reproductive, neurological, and immune abnormalities observed in both humans and marine wildlife.

1.4.4 HEALTH PROBLEMS CAUSED BY WATER POLLUTION

Water pollution can lead to various diseases and health issues, including waterborne illnesses such as cholera and typhoid, water-washed conditions like trachoma and typhus, and water-based diseases such as schistosomiasis. Millions of people die every year due to the drinking of unclean water and inadequate sanitation, as outlined below in data from Statista. According to the University of Wales' Centre for Research into Environment and Health, there is an almost endless list of infectious, toxic, neurologic, hematologic, and gastrointestinal water pollution diseases. The 2019 World Health Organization report on "Safer water, better health" lists 12 to 14 major diseases, adverse health outcomes or injuries that is associated in part with contaminated water.

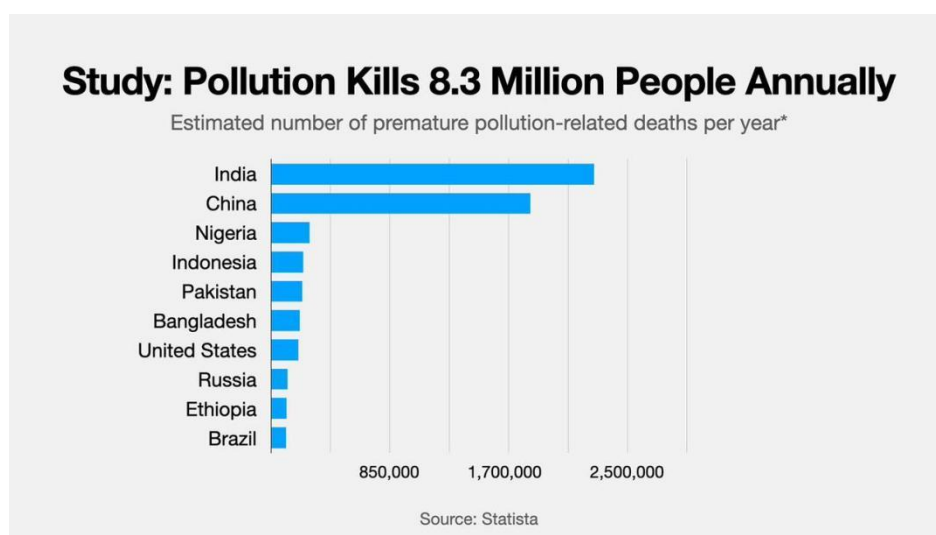


Fig 1.4 Pollution Related Death Chart

The World Health Organization categorizes diseases resulting from water pollution and inadequate clean water access as "Water-Related Diseases." These ailments are classified into three primary types: waterborne, water-washed, and water-based. Waterborne diseases stem from ingesting water tainted by pathogens from human or animal waste, encompassing enteric and diarrheal illnesses like cholera, typhoid, amoebic and bacillary dysentery, alongside various other diarrheal and non-

diarrheal conditions. Waterborne diarrhoeal diseases are estimated to affect over 1 billion people and cause 2.2 to 5 million deaths annually.

Water-washed diseases occur when contaminated water is used for washing and personal hygiene. Water-washed diseases, like trachoma and typhus, are spread directly from person to person. For instance, trachoma, a blinding infectious conjunctivitis caused by *Chlamydia trachomatis*, is closely linked with the absence of nearby sources of safe, uncontaminated water.

These diseases are part of the broader category of "Water-Related Diseases," as defined by the World Health Organization, which also includes waterborne and water-based ailments. Waterborne diseases arise from ingesting water contaminated by pathogens from human or animal waste, encompassing enteric and diarrheal conditions such as cholera, typhoid, amoebic and bacillary dysentery, as well as numerous other diarrheal and non-diarrheal illnesses. Waterborne diarrhoeal diseases are estimated to affect over 1 billion people and cause 2.2 to 5 million deaths annually.

Water-washed diseases emerge when contaminated water is utilized for washing and personal hygiene purposes. These ailments encompass conditions like trachoma and typhus, which spread from person to person. For instance, trachoma, characterized by blinding infectious conjunctivitis caused by *Chlamydia trachomatis*, is notably linked with the lack of accessible, uncontaminated water sources nearby. On the other hand, water-based diseases arise when individuals consume or use water contaminated by parasites. The most common form of water-based disease is Schistosomiasis, a type of parasitic disease, which affects over 200 million people every year and causes nearly 200 thousand deaths.

The World Health Organization's classification of water-related diseases predominantly emphasizes infectious diseases resulting from water biocontamination. However, a wide spectrum of other health issues and diseases arise from water pollution. For instance, exposure to chemical and heavy metal pollutants in water can lead to liver damage. Neurologic toxicity from pesticides and heavy metals.

Disorders of reproduction and sexual maturation, particularly from pollutants like perchlorate which disrupt the endocrine hormones which govern sexual maturation and reproduction. Oncologic disorders of the gastrointestinal, urinary, and reproductive tracts can occur with numerous pollutants. For example, the International Agency for Research on Cancer has classified water contaminants such as arsenic, fluoride, nitrate, Microcystin-LR, and various halo acetic acids as carcinogenic to humans.

1.4.5 DEATH STATISTICS

The estimated number of deaths attributed to water-related illnesses ranges between 2 and 5 million annually.

Table 1.1 Death by Water Pollution Statistics

SOURCE	DEATHS PER YEAR BY WATER POLLUTION
World health organization 2022	1.4Million
World health organization 2019	2.8Million
World health organization 2000	3.6Million
World health organization 1992	4Million

According to the World Health Organization, nearly 2 billion people worldwide lack access to safe drinking water. Approximately 829 thousand individuals, including 297 thousand children under the age of 5, are estimated to die each year from water pollution-related diseases, particularly infectious diarrhea.

However, a report by the Pacific Institute highlights the inadequacy of monitoring and reporting on morbidity and mortality from water-related illnesses, rendering all statistics rough estimates.

Data from the 2017 Global Burden of Disease Study by the United States Institute for Health Metrics and Evaluation (IHME) provides insight into the death rate per 100,000 individuals attributed to unsafe water sources in select countries. While

the death rate in developing nations has seen a sharp decline over time, any increases observed in developed countries remain at very low levels.

1.5 PHYTOREMEDIATION METHOD

Phytoremediation is an environmental remediation method that uses plants to mitigate and clean up pollution in soil, water, and air. It involves the cultivation of specific plants, known as hyperaccumulators or tolerant species, to absorb, immobilize, or break down various contaminants, such as heavy metals, organic pollutants, and even radioactive materials. Through their roots and associated microorganisms, these plants can remove or reduce the concentration of contaminants, making phytoremediation an eco-friendly and cost-effective approach to environmental cleanup.

Phytoremediation, among available processes, stands out as a novel method for water pollution cleanup. This approach utilizes plants due to their significant interaction with water bodies, surrounding media, and microorganisms. Moreover, plants play a positive role in removing contaminants from water, making phytoremediation an effective and environmentally friendly solution to address water pollution. This approach harnesses the natural abilities of certain plant species to absorb, accumulate, and detoxify contaminants from the environment. Phytoremediation is considered a cost-effective and low-impact method for addressing various types of pollution, including soil and water contamination from heavy metals, organic pollutants, and other hazardous substances.

1.6 PLANTS USED IN PHYTOREMEDIATION

Phytoremediation relies on the use of specific plants known as hyperaccumulators or tolerant species that have the ability to absorb, accumulate, or transform contaminants from the environment. The choice of plants depends on the type of pollutants present and the specific phytoremediation method being employed. Here are some examples of plants commonly used in phytoremediation.

Table 1.2 Types of Plant Used in Phytoremediation Method

TYPES	BENEFITS
 Water Hyacinth	Effective in removing excess nutrients like nitrogen and phosphorus, heavy metals, and some organic pollutants from water. Also helps improve water quality by increasing dissolved oxygen levels.
 Duckweed	Rapid growth and high nutrient uptake make duckweed suitable for removing nutrients like nitrogen and phosphorus. It can also absorb heavy metals and some organic compounds.
 Cattails	Particularly useful for treating municipal wastewater and agricultural runoff. Cattails can take up nutrients, heavy metals, and some organic contaminants. They also provide habitat for wildlife.



Willows

Often used in constructed wetlands, willows can absorb nutrients and heavy metals from water. They also provide erosion control



Reed

Useful for removing nutrients and heavy metals from water and stabilizing shorelines. Phragmites is commonly found in wetland restoration projects.



Water Lettuce

Effective in absorbing nutrients and heavy metals from water, particularly in warmer climates. It also provides habitat for aquatic organisms.



Algae

Microalgae and macroalgae can absorb nutrients, heavy metals, and organic pollutants from water

CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL

The following major research project has been taken from international journals as reference to analyze the concepts for the project.

2.2 REVIEW OF THE LITERATURE

Priyanka Saha, Omkar Shinde and Supriya Sarkar (2019) conducted an assessment of heavy metal accumulation in water hyacinth from tannery effluent. Their findings shed light on the extent of heavy metal uptake by water hyacinth, providing valuable insights into its suitability for phytoremediation applications in tannery wastewater treatment.

Pradeep Kumar, Vikas Kumar, and Renu Singh (2019) reviewed the role of aquatic plants in Phyto-remediation of heavy metal-contaminated water. Their review highlighted the importance of aquatic plants, including water hyacinth, in mitigating heavy metal pollution in water bodies, emphasizing their ecological significance.

Anand Narayanan P. Balamurugan and K. Shunmugapriya, (2018) investigated the phytoremediation potential of water hyacinth in reducing heavy metal content from industrial effluent. Their study demonstrated the effectiveness of water hyacinth in removing heavy metals, highlighting its potential for industrial wastewater treatment.

Deepika Sharma, Anil Kumar Sharma, and Sudhir Kumar Sharma (2018) evaluated the efficiency of water hyacinth in removing heavy metals from industrial effluents through a case study. Their findings demonstrated the effectiveness of water hyacinth in reducing heavy metal concentrations in industrial wastewater, highlighting its potential for industrial wastewater treatment.

Praveen Kumar, Binita Kumari, and Pawan Kumar Singh (2017) conducted a review on the phytoremediation potential of water hyacinth for removal of heavy metals from industrial effluent. Their review synthesized existing literature on water hyacinth-

based Phyto-remediation, highlighting its effectiveness and applicability in industrial wastewater treatment.

Jyoti Yadav, Amrita Singh, and Anupam Verma (2017) conducted a review on water hyacinth as a potential tool for phytoremediation of heavy metals. Their review synthesized existing literature on water hyacinth-based Phyto-remediation, emphasizing its versatility and effectiveness in removing heavy metals from contaminated environments.

Vandana Singh and Shalini Srivastava (2016) reviewed the phytoremediation potential of water hyacinth for removal of heavy metals from wastewater. Their review provided an overview of the mechanisms involved in water hyacinth-based phyto-remediation and its applications in wastewater treatment.

Shalini Srivastava and Mukesh Pandey (2016) evaluated the efficacy of water hyacinth in removing heavy metals from industrial effluents. Their study demonstrated the efficiency of water hyacinth as a bio-remediator, suggesting its use as a cost-effective and sustainable solution for industrial wastewater treatment.

Arjun Prasad, Pawan Kumar Singh, and Sanjay Kumar Gupta (2015) investigated the Phyto-remediation of heavy metals from tannery effluent using water hyacinth. Their case study demonstrated the efficacy of water hyacinth in removing heavy metals from tannery effluent, suggesting its potential for use in tannery wastewater treatment.

Rajesh Kumar Singh and Rajesh Kumar Dubey (2014) reviewed the phytoremediation of heavy metal contaminated sites using water hyacinth. Their comprehensive review summarized the existing research on water hyacinth-based Phyto-remediation and highlighted its potential for remediation of contaminated sites.

2.3 INFERENCE FROM THE LITERATURES

- [1] Water hyacinth is a highly effective plant for the phytoremediation of water contaminated with various pollutants, including heavy metals, organic compounds, and nutrients.

- [2] Water hyacinth effectively reduces heavy metal content in industrial effluent, showcasing its potential as a phytoremediation tool.
- [3] Significance of water temperature, pH, and nutrient levels in the aquatic environment, as they can significantly influence the success of water hyacinth in treating water.
- [4] The versatility of water hyacinth is evident as it successfully treats various industrial effluents, including those from tanneries.
- [5] Propagating water hyacinth through sustainable and controlled methods is crucial to maintain a consistent source for water treatment projects.
- [6] Research elucidates mechanisms such as adsorption and absorption for contaminant uptake by water hyacinth.
- [7] Field studies validate the practical effectiveness of water hyacinth in real-world remediation scenarios.
- [8] Integration of water hyacinth with other methods, like constructed wetlands, enhances heavy metal removal efficiency.
- [9] Combining water hyacinth with other treatment technologies can enhance overall remediation efficiency, creating synergistic effects.
- [10] Water hyacinth can help in the removal of excess nutrients like nitrogen and phosphorus, which are often present in industrial wastewater and can contribute to eutrophication.

2.4 AIM OF THE STUDY

The aim of this study is to design and assess the efficiency of an integrated phytoremediation system utilizing water hyacinth within a constructed wetland pond environment. The primary focus is on the removal of heavy metals from wastewater effluent. Through the implementation of this system, the goal is to develop a sustainable and cost-effective method for water purification. By evaluating the performance of the system, this research aims to contribute to the advancement of eco-friendly approaches to water remediation, addressing environmental concerns and promoting ecological sustainability.

2.5 OBJECTIVE OF THE STUDY

1. Collecting Groundwater Samples from the Study Area:
 - This objective involves gathering representative samples of groundwater from various locations within the study area.
 - The collected samples will serve as the basis for further analysis to assess the presence and concentration of contaminants.
2. Analyzing Contaminants Present in Wastewater:
 - This objective focuses on identifying and quantifying the various contaminants present in wastewater sources within the study area.
 - Common contaminants of interest may include heavy metals, organic pollutants, nutrients, and pathogens.
3. Identifying a Suitable Sustainable Solution for Treating Contaminated Water:
 - This objective aims to explore and evaluate various treatment technologies and approaches for effectively removing contaminants from the water.
 - Sustainable solutions prioritize methods that minimize environmental impact, energy consumption, and operational costs while achieving effective treatment outcomes.
 - The selected solution should be tailored to the specific characteristics of the contaminants present in the water and consider factors such as scalability, feasibility, and community acceptance.
4. Investigating the effectiveness of water hyacinth in removing heavy metals from wastewater effluent within the constructed wetland environment.
5. Monitoring the water quality parameters before and after treatment to assess the efficiency of heavy metal removal.
6. Evaluating the growth and health of water hyacinth plants as indicators of their suitability for phytoremediation.

CHAPTER 3

METHOD OF INVESTIGATION

3.1 METHODOLOGY

The methodology of the experimental study is shown in the below Fig 3.1,

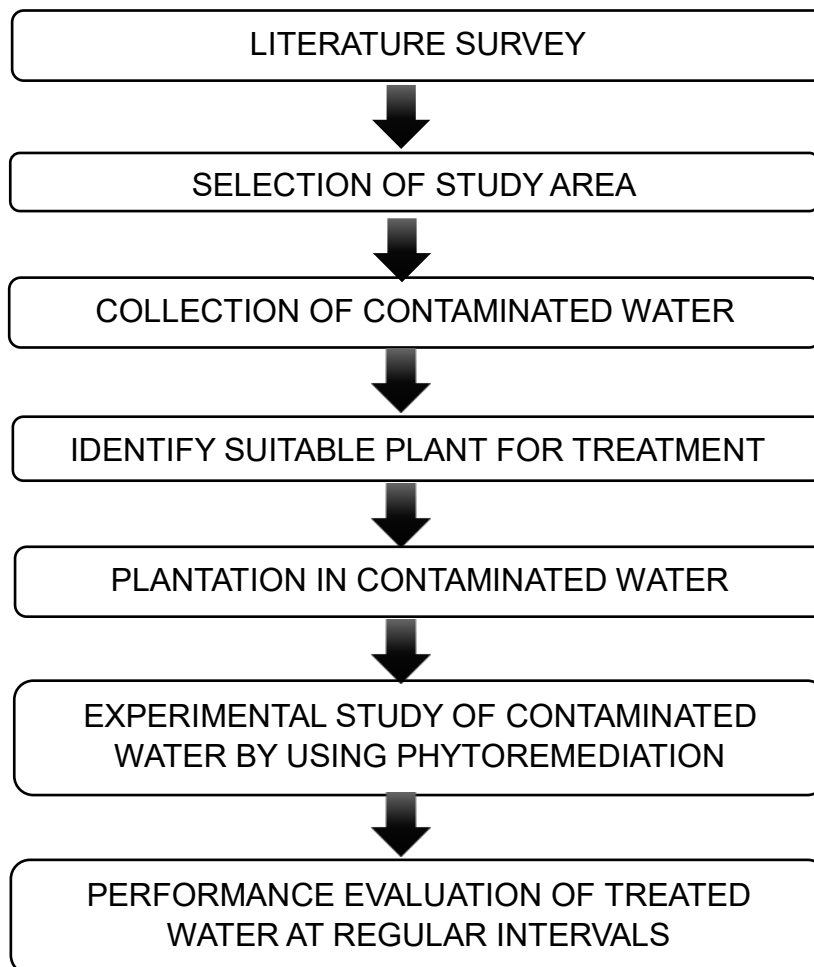


Fig 3.1 Flowchart of methodology

3.2 STUDY AREA

The research area chosen for this study is Nagalkeni, located in the Kanchipuram District of Tamil Nadu. Its geographical coordinates are approximately 12.96 degrees latitude and 80.14 degrees longitude. Nagalkeni is the study area because the water in this area is heavily polluted majorly due to the tannery industry and many other industries situated in this area. The groundwater in Nagalkeni has been significantly compromised due to the discharge of untreated sewage and wastewater from the tannery industry. The tannery industry wastewater contained heavy metals particularly Chromium, which is carcinogenic to human beings. The porous media, including the soil, and groundwater in Nagalkeni, have faced contamination due to the discharge of untreated and partially treated wastewater from the tannery industry onto the land.



Fig 3.2 Study area – Nagalkeni

Chromium available in tannery industry wastewater exists in the form of Cr (III) and Cr (VI), Cr (III) is only toxic at high concentrations, whereas hexavalent Cr (VI), is considered more toxic to all living beings and the environment when concentration of Cr (VI) exceeds the tolerance limit of 0.05 mg/L (BIS drinking water specification - IS 10500:2004).

3.3 TANNERY INDUSTRY WATER

The tannery industry holds a crucial position in the economy, contributing significantly to employment and trade. However, it also presents a severe environmental threat due to its substantial water and chemical usage, resulting in the generation of wastewater containing high concentrations of pollutants. This effluent comprises a diverse array of contaminants derived from various stages of the leather manufacturing process, complicating the disposal process for the industry. The tanning process also contributes significantly to the pH, biological oxygen demand (BOD), total suspended solids (TSS), chemical oxygen demand (COD), total dissolved solids (TDS), and concentrations of Cr (II), Cr (III), Cr (VI), Cl⁻, sulfate, sulfide, and inorganic constituents in the wastewater.



Fig 3.3 Contaminated Water from Tannery Industry

3.4 PROCESS DESCRIPTION IN TANNERY INDUSTRY

- **Soaking:** Soaking is done to remove any excess salt or dirt. All non-leather making components should be removed from the hide to prepare for the production a clean and flat pelt.

- *Liming*: The objective of liming in the leather processing industry is to break down the fiber bundles and eliminate any unwanted hair from the hide by introducing an alkaline environment.
- *De-hairing*: After fleshing and/or splitting, it is crucial to thoroughly remove lime and neutralize any residual alkalinity from the pelt. This process is typically achieved using proprietary organic acids and acid-salts, which form highly soluble lime complexes.
- *Bating*: The network of elastin fibers, which remain insoluble in the highly alkaline conditions of liming, can be successfully relaxed and flattened through the extended activity of specific enzyme preparations.
- *Pickling*: Acids are added to slacken the pelt and enhance penetration of the tanning agent.
- *Tanning*: Through the application of a tanning agent, the collagen structure of the pelt undergoes a transformation, resulting in the conversion of the hide into a leather intermediate.



Fig 3.4 Effluents in tannery industry

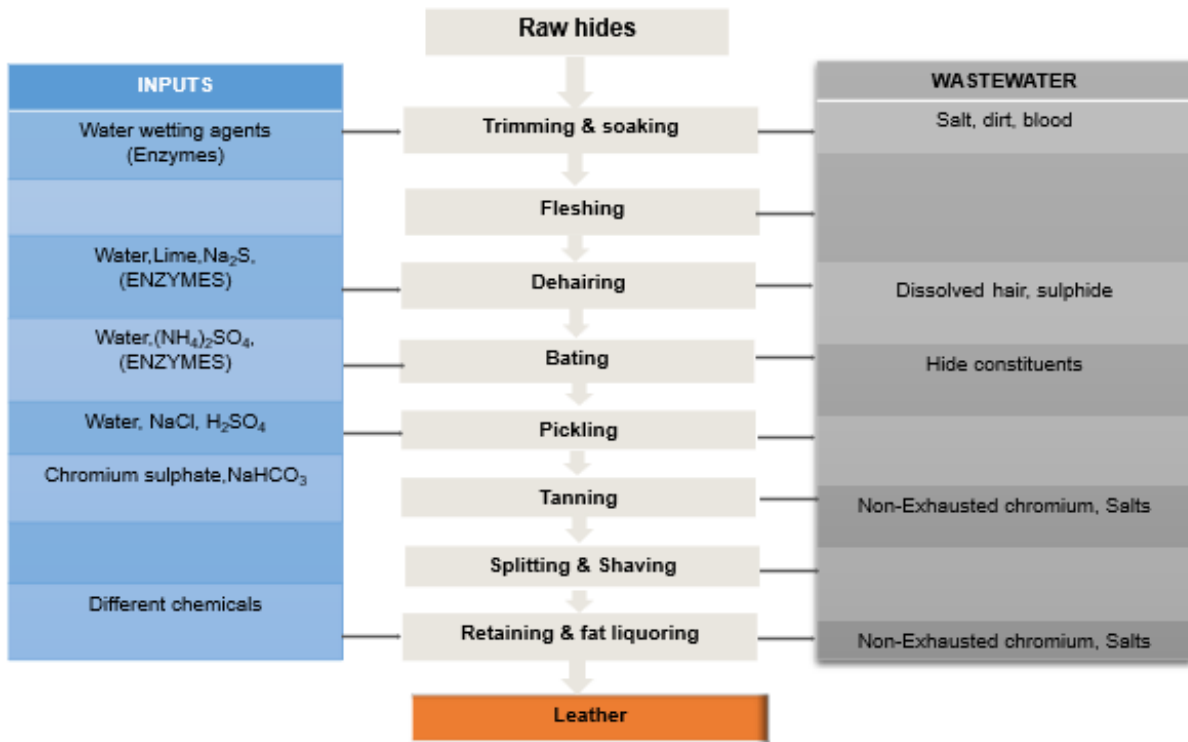


Fig 3.5 Process involved in Tannery industry

3.5 AQUATIC PLANT

Aquatic plants play a crucial role in phytoremediation, a natural process that utilizes plants to remove contaminants from water bodies. Species such as water hyacinth, duckweed, and water lettuce are particularly effective due to their ability to absorb nutrients and filter out pollutants like heavy metals, pesticides, and excess nutrients. These plants not only enhance water quality but also provide habitats for various aquatic organisms. Phytoremediation offers a sustainable and cost-effective solution for mitigating water pollution, contributing to the restoration and preservation of aquatic ecosystems.

3.5.1 WATER HYACINTH (*EICHHORNIA*)

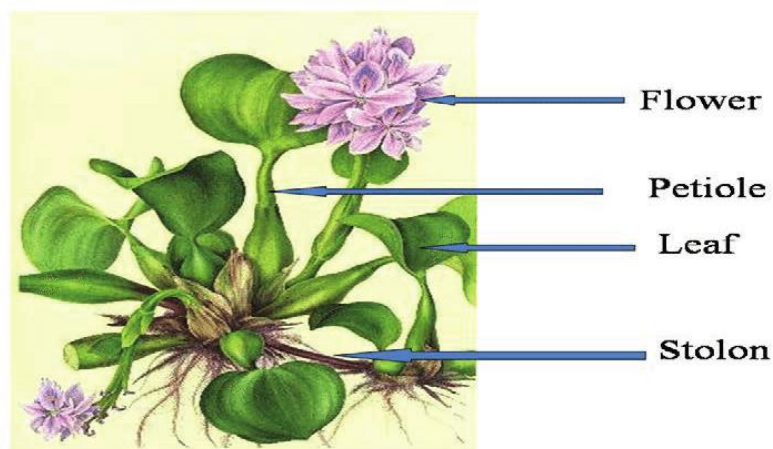


Fig 3.6 Water hyacinth (*Eichhornia*)

Eichhornia, commonly known as water hyacinth, can be used in the treatment of textile industry wastewater due to its phytoremediation capabilities. Eichhornia is known for its ability to absorb and accumulate various pollutants from water, including heavy metals, organic dyes, and other contaminants commonly found in textile industry wastewater. Water hyacinth (*Eichhornia crassipes*) is an aquatic vascular plant characterized by rounded, upright, and shiny green leaves, often adorned with lavender flowers resembling orchids. This plant species is known for its fast growth and perennial nature, possessing significant reproductive potential. The Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 4 to 10. This is very important fact because it points that water hyacinth can be used for treatment of different types of waste water. Optimal water temperature for growth is 28° C to 30° C. Temperatures above 33° C inhibit further growth. The roots of Eichhornia can absorb and concentrate pollutants. In the case of textile wastewater, this can be particularly effective in removing dyes, residual chemicals, and heavy metals that are often present in the effluent.

Water hyacinth is highly effective at absorbing nutrients from water, particularly nitrogen and phosphorus. This makes it useful in the remediation of water bodies contaminated with excess nutrients, such as those affected by agricultural runoff or sewage discharges. The plant can help reduce nutrient pollution and prevent issues

like eutrophication. Water hyacinth can also accumulate heavy metals like cadmium, lead, and chromium from water. The roots of the plant tend to accumulate these metals, helping to reduce their concentration in the water. In Wastewater Treatment Water hyacinth has been used in constructed wetlands. It can help remove organic pollutants and suspended solids from sewage and industrial wastewater, improving water quality before discharge.

3.6 SAMPLE COLLECTION

Table 3.1 Table of samples latitude and longitude

SL. NO	SAMPLE AREA	LATITUDE	LONGITUDE	SOURCE
1	Dr Abdul Kalam Street	12°57'40"N	80°07'59"E	Bore well
2	Neelakandan St	12°57'44"N	80°08'00"E	Bore well
3	Km Adam Salai	12°57'41"N	80°08'04"E	Bore well
4	Adam Tannery St	12°57'45"N	80°08'03"E	Bore well
5	MGR Road	12°57'41"N	80°08'03"E	Bore well
6	Alamelu Tannery Industry	12°57'40"N	80°07'59"E	Surface water



Fig 3.7 Process of collecting samples



Fig 3.8 Sampling points location

In this project a systematic approach was undertaken to collect water samples, crucial for assessing the region's water quality. Following established protocols, trained personnel strategically selected sampling sites representing various water sources across Nagalkeni. Prior to collection, all sampling equipment was meticulously cleaned and sterilized to prevent contamination. Samples were collected using sterile containers, ensuring accuracy and reliability. Multiple samples were taken at each site, capturing variations in water quality across different depths. Comprehensive documentation, including GPS coordinates, date, time, and any pertinent observations, accompanied each sample to provide context for analysis. Quality control measures, such as duplicate samples and field blanks, were incorporated to ensure data integrity. Table 3.1 shows the latitude and longitude of sample location around the study area. The bore water and surface water samples had been collected and analyzed for physiochemical parameters.



Fig 3.9 Tannery industry sample

3.7 EXPERIMENTAL INVESTIGATION

The experimental investigation was carried out in two ways which is a batch test and a real time test in artificial wet land pond.

3.7.1 PLANTATION IN EFFLUENT (BATCH TEST):

A small-scale experiment was conducted to assess the efficacy of using water hyacinth (*Eichhornia crassipes*) for treating tannery effluent. The experimental setup consisted of a 15-liter capacity tub filled with tannery effluent obtained from the tannery industry. Water hyacinth plants were carefully transplanted into the tub, where they were allowed to grow and interact with the effluent. Throughout the experiment, regular monitoring and observations were conducted to track changes in the effluent and the growth of the water hyacinth plants. Parameters such as pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) were measured at predetermined intervals to assess the effectiveness of the treatment process. Qualitative observations of water hyacinth growth and overall changes in

water quality was also documented.



Fig 3.10 Plantation in effluent

3.7.2 PLANTATION IN EFFLUENT (REAL TIME TEST):

In our pursuit to extend the efficacy of water hyacinth in treating tannery effluent, we scaled up our experiment to a larger artificial wetland pond, boasting a capacity of 150 liters. This expansion facilitated the creation of a more comprehensive treatment system, allowing for a greater volume of effluent to be processed. To optimize pollutant removal efficiency, the pond was populated with a total of 75 water hyacinth plants strategically placed throughout the water body. Throughout the duration of the experiment, a rigorous regimen of regular testing was implemented. This encompassed a spectrum of water quality parameters, including pH levels, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS). By meticulously tracking these metrics, we aimed to gain a nuanced understanding of the treatment process's effectiveness and the water hyacinth's capacity to remediate contaminants. The larger-scale endeavor not only replicated real-world scenarios more

closely but also provided insights into the scalability of water hyacinth-based treatment systems. By extrapolating our findings from the 15-liter tub to this expanded 150-liter pond shown in figure 3.11.



Fig 3.11 Plantation in wetland pond

3.7.3 TESTING WATER SAMPLE PARAMETERS:

Testing treated water is crucial to ensure its quality and safety before it is released into the environment or used for various purposes. The specific tests to be performed on treated water can vary depending on the source of the water, the treatment processes applied, and its intended use. Here are some common tests typically conducted on treated water

- i. *pH Level*: Measurement of the water's acidity or alkalinity to ensure it falls within an acceptable range for the intended use.
- ii. *Turbidity*: Determining the cloudiness or clarity of the water, which can indicate the presence of suspended particles.
- iii. *Total Dissolved Solids (TDS)*: Determining the concentration of dissolved solids in the water, including salts and minerals.

- iv. *Nutrient Levels*: Testing for the presence of nutrients like nitrogen and phosphorus, which can contribute to eutrophication.
- v. *Heavy Metals*: Analyzing for the presence of toxic heavy metals such as lead, mercury, cadmium, and chromium.
- vi. *Microbiological Testing*: Identifying and quantifying the presence of bacteria, viruses, and other microorganisms to ensure the water is free from harmful pathogens.
- vii. *Residual Chemicals*: Checking for any residual chemicals or treatment agents used in the water treatment process, such as chlorine or other disinfectants.
- viii. *Color and Odor*: Assessing the visual appearance and smell of the water to detect any abnormalities.
- ix. *Taste*: Evaluating the taste of the water to ensure it is palatable and free from off-flavors.

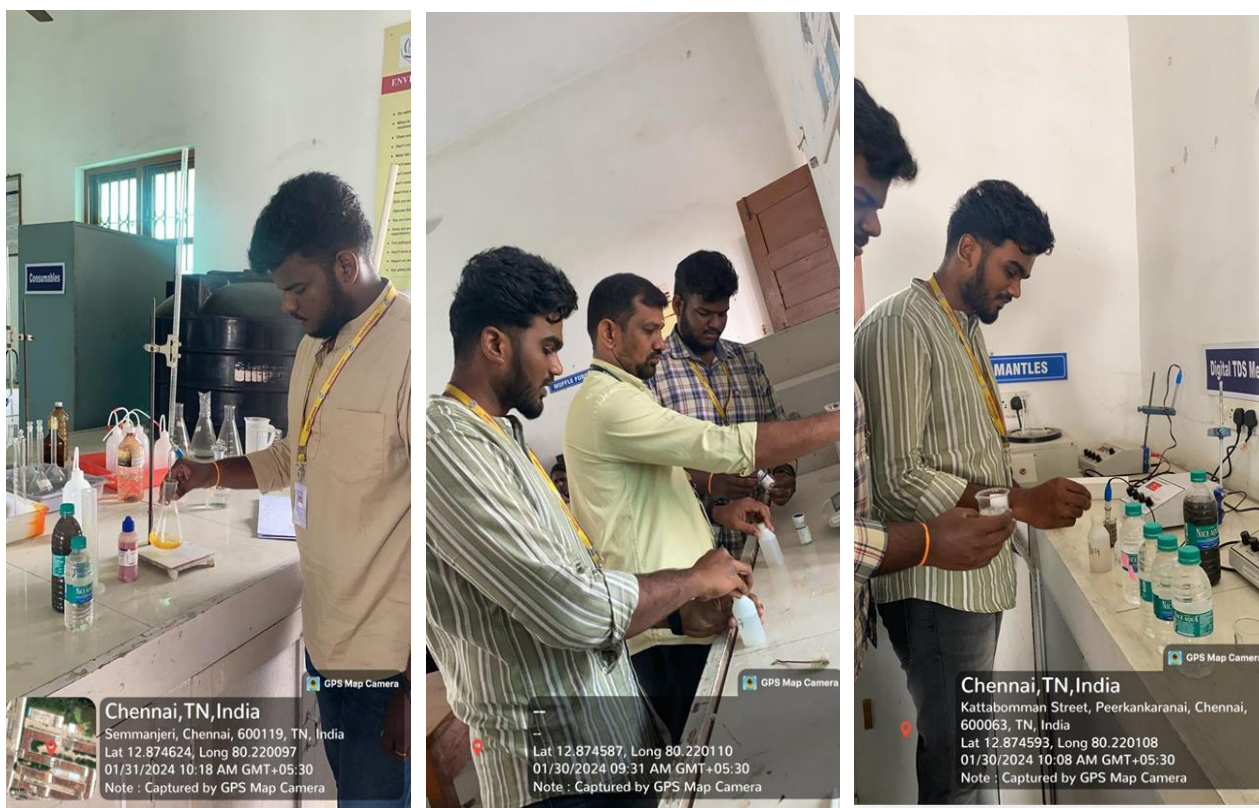


Fig 3.12 Analysis of water sample

3.7.4 SYNTHESIS OF LEAD CHLORIDE SOLUTION

As part of our research on water hyacinth's efficacy in treating industrial effluents, we introduced a synthetic solution containing lead chloride (PbCl_2) to our experimental setup. This solution was meticulously prepared by dissolving 27.81 grams of PbCl_2 (100% purity) in deionized or distilled water to achieve a concentration of 0.1 mol/L. Following complete dissolution, the solution was diluted to a final volume of 1 liter. This synthetic solution was incorporated into our large-scale treatment experiment to simulate heavy metal contamination commonly found in industrial wastewater, allowing us to evaluate water hyacinth's effectiveness in treating lead-contaminated effluents.



Fig 3.13 Lead chloride powder

3.8 PLANT STUDY

Water hyacinth is fast growing perennial aquatic macrophyte. It is a member of pickerelweed family. This tropical plant spread throughout the world in late 19th and early 20th century. Water hyacinth is renowned for its remarkable reproductive capacity, capable of doubling its population in a mere twelve days under favorable conditions. Moreover, this invasive plant species exhibits an extraordinary ability to thrive in severely polluted waters, making it a significant concern for aquatic

ecosystems worldwide. Similar to other biological processes, the growth of water hyacinth is intricately tied to a multitude of ecological factors.

3.8.1 **GROWTH RATE OF PLANT IN EFFLUENT:**

The qualities of water and air temperatures are indeed significant limiting factors for the regular development and growth of plants. Water hyacinth is growing fastest at temperatures from 20° C to 30° C, but growth fully stops at temperatures from 8° C to 15° C. The growth rate of water hyacinth is 33 gm/week in normal water. To understand the growing ability of water hyacinth, its growth rate was studied in effluent. From the fig 3.13 it can be concluded that the growth of water hyacinth decreases in effluent as the plant absorbs the heavy metals and all the other substance.

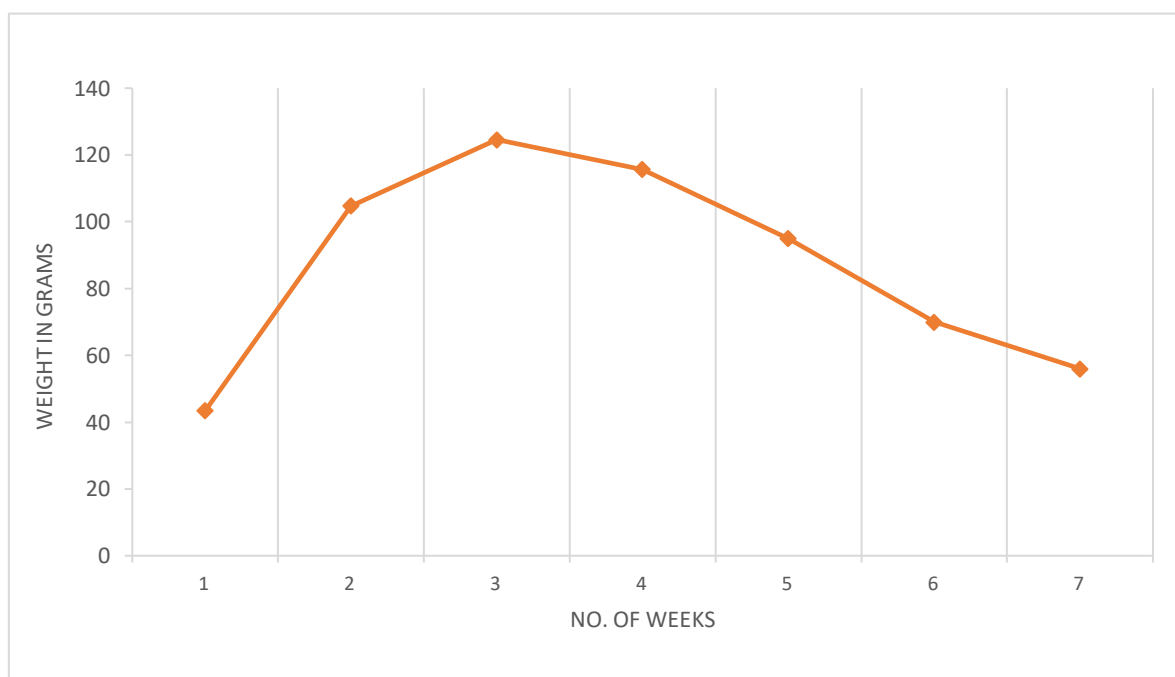


Fig 3.14 Growth rate of plant

CHAPTER 4

RESULTS AND DISCUSSION

4.1 EXPERIMENTAL RESULTS – BORE SAMPLES

In this section, the laboratory results obtained from the analysis of bore samples collected from the study area is tabulated. The analysis focused on assessing various physicochemical parameters, including pH levels, dissolved oxygen (DO) concentrations, turbidity, total dissolved solids (TDS), and the presence of specific contaminants such as heavy metals and organic compounds. These results provide crucial insights into the overall water quality and potential pollution levels in the bore samples, forming the basis for understanding the environmental conditions and informing subsequent discussions on mitigation strategies and conservation efforts.

Table 4.1 Physical and Chemical parameter of bore sample

Parameters	S1	S2	S3	S4	S5
Appearance	Clear	Clear	Clear	Clear	Clear
Colour	Pale yellow	Colourless	Colourless	Colourless	Colourless
Odour	Odorless	Odorless	Odorless	Odorless	Odorless
Turbidity	0 NTU	0 NTU	0 NTU	0 NTU	0 NTU
Total dissolved solids	851 mg/l	823 mg/l	818 mg/l	798 mg/l	816 mg/l
Electrical Conductivity	1389 mg/l	1314 mg/l	1380mg/l	1297 mg/l	1410 mg/l

Total Hardness	570 mg/l	561 mg/l	512mg/l	549 mg/l	588 mg/l
Total Alkalinity	456 mg/l	461 mg/l	475 mg/l	499 mg/l	443 mg/l

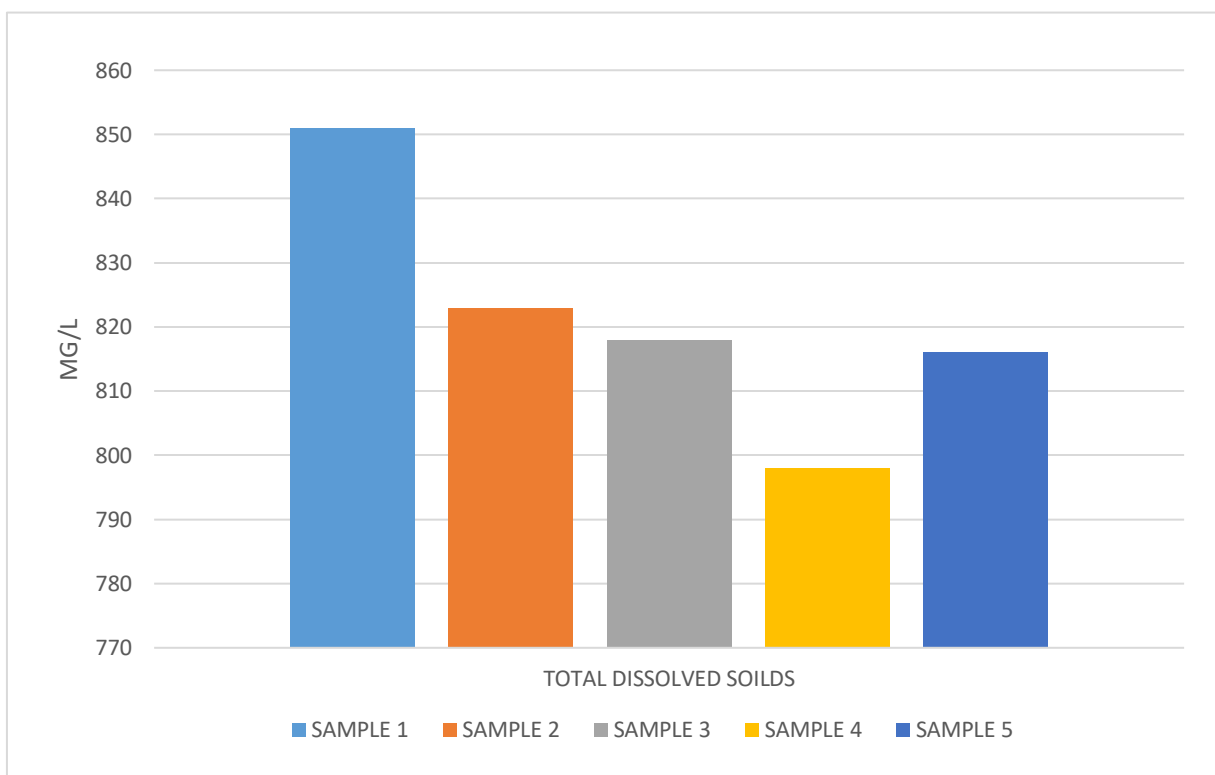


Fig 4.1 TDS of bore sample

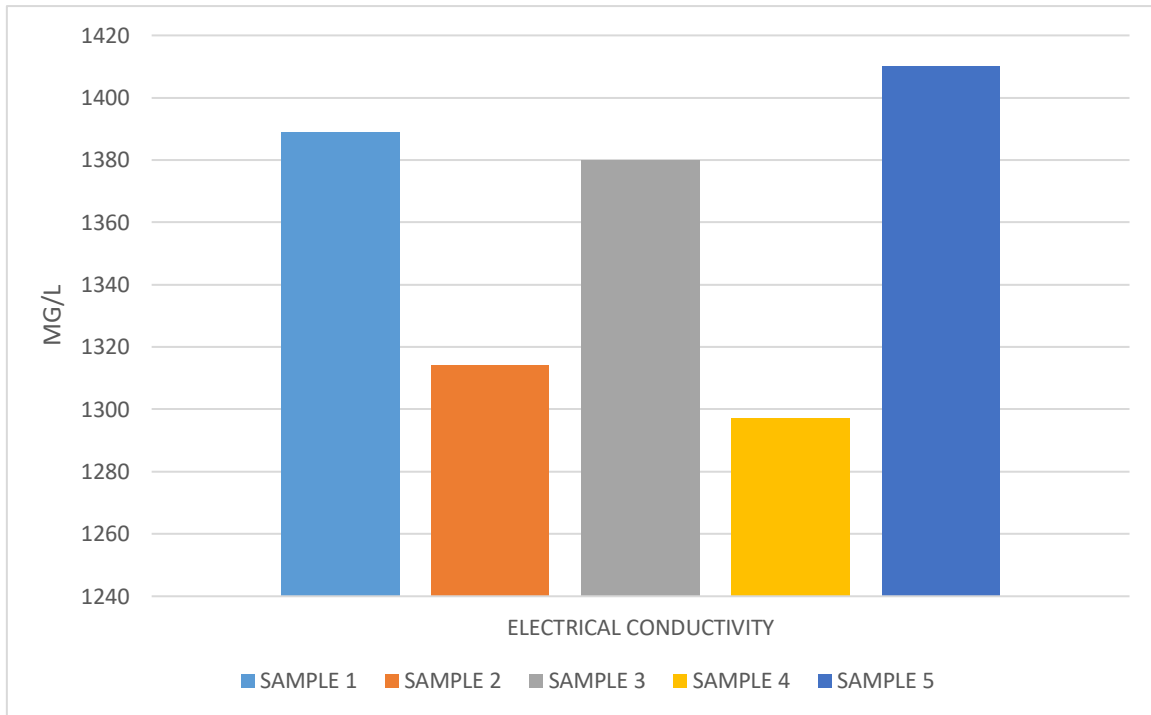


Fig 4.2 Electrical conductivity of bore sample

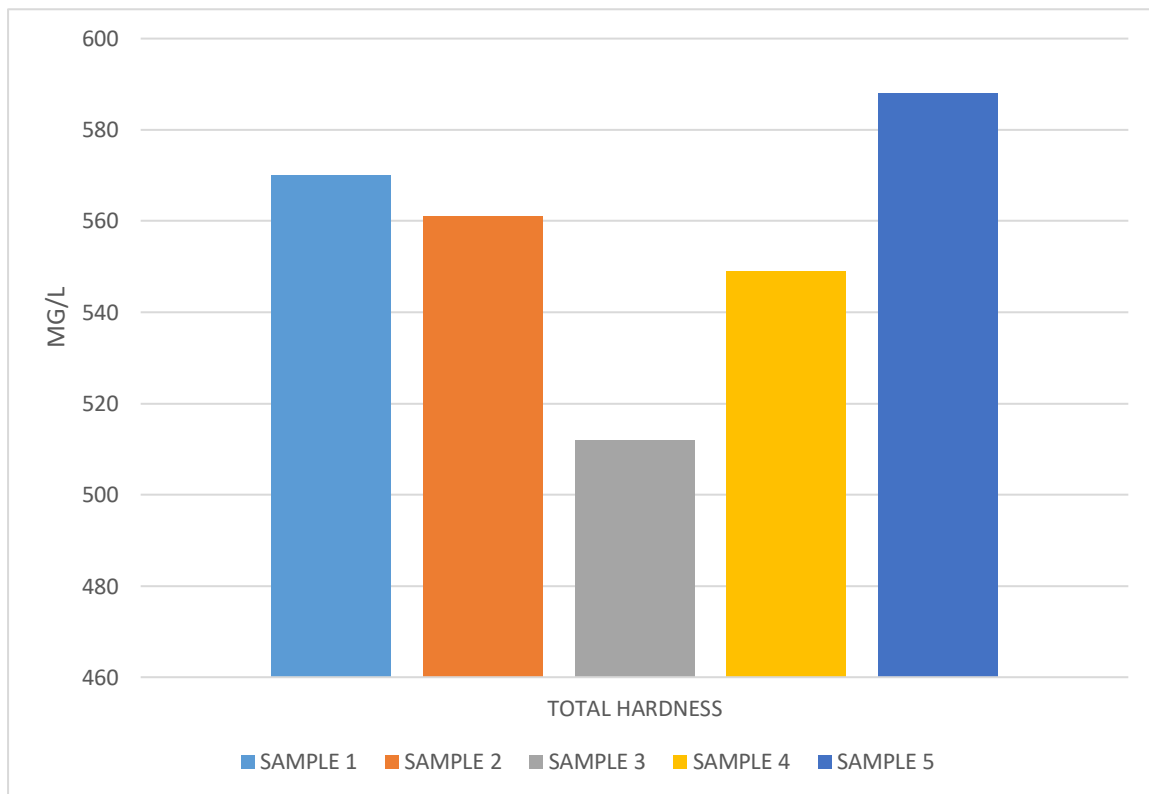


Fig 4.3 Hardness of bore sample

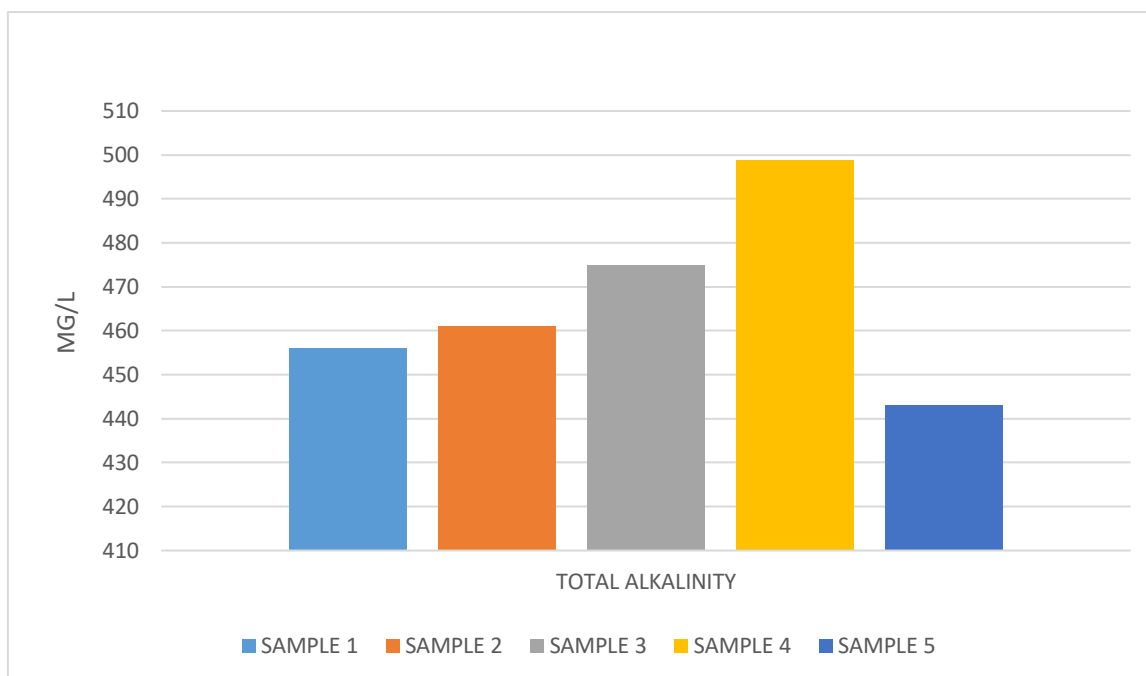


Fig 4.4 Alkalinity of bore sample

4.2 BATCH RESULTS FOR TANNERY INDUSTRY EFFLUENT (BATCH TEST)

The laboratory findings from basic physical parameters to heavy metal concentrations obtained from the analysis of tannery industry effluent in a small-scale experimental setup is listed below. The parameters encompassing appearance, color, and odor serve as initial indicators of effluent quality, while measurements of turbidity and conductivity offer insights into the clarity and electrical conductivity of the effluent, respectively. Additionally, the analysis includes the quantification of various heavy metals present, each carrying potential environmental and health implications. Through graphical representations, these results provide a comprehensive depiction of the effluent's characteristics, facilitating the assessment of its environmental impact and aiding in the development of targeted remediation strategies.

Table 4.2 Physical parameters of tannery industry effluent

Physical Parameters	Before Treatment (30.1.2024)	10 Days of Treatment (13.2.2024)	20 Days of Treatment (23.2.2024)
Appearance	Slightly Turbid	Slightly Turbid	Slightly Turbid
Colour	Dark grey in colour	Light grey in colour	Pale yellow in colour
Odour	Unpleasant smell	Unpleasant smell	Nil

Table 4.3 Chemical parameters of tannery industry effluent

Chemical parameters	Before treatment	After treatment		% of reduction
		10 Days of treatment	20 Days of treatment	
Turbidity	18 NTU	16 NTU	12 NTU	40%
Electrical conductivity	1499 s/m	1385 s/m	1750 s/m	9.56%
PH	8.5	7.8	7.45	12.35%
Total dissolved solids	1051 mg/l	1045 mg/l	1000 mg/l	4.98%
Total hardness	421 mg/l	380 mg/l	300 mg/l	40.33%
Total alkalinity	413 mg/l	397 mg/l	360 mg/l	14.72%

Sulphate	156 mg/l	126 mg/l	110 mg/l	41.82%
Calcium	58 mg/l	49 mg/l	45 mg/l	28.89%
Magnesium	70.8 mg/l	64.76 mg/l	58 mg/l	22%
Nitrate	12 mg/l	9 mg/l	8.45 mg/l	41%
Chloride	1830 mg/l	1670 mg/l	1541 mg/l	18.75%
Chromium	7224 mg/l	6800 mg/l	5884 mg/l	22.76%

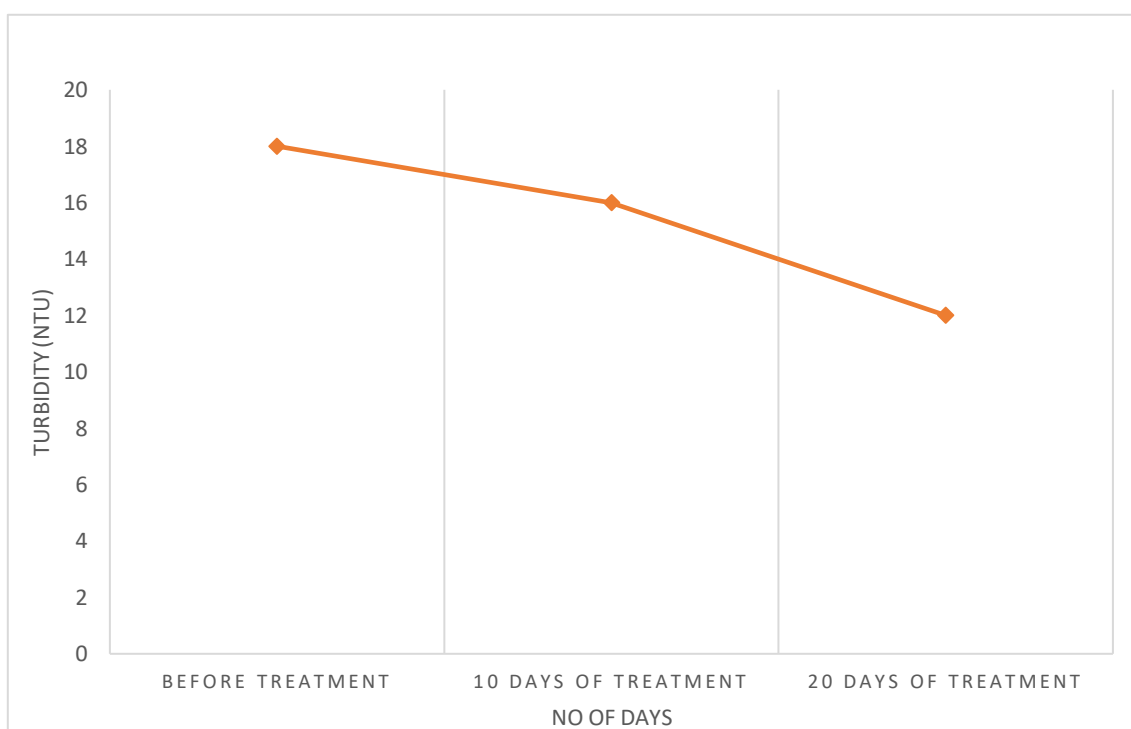


Fig 4.5 Turbidity values before and after treatment

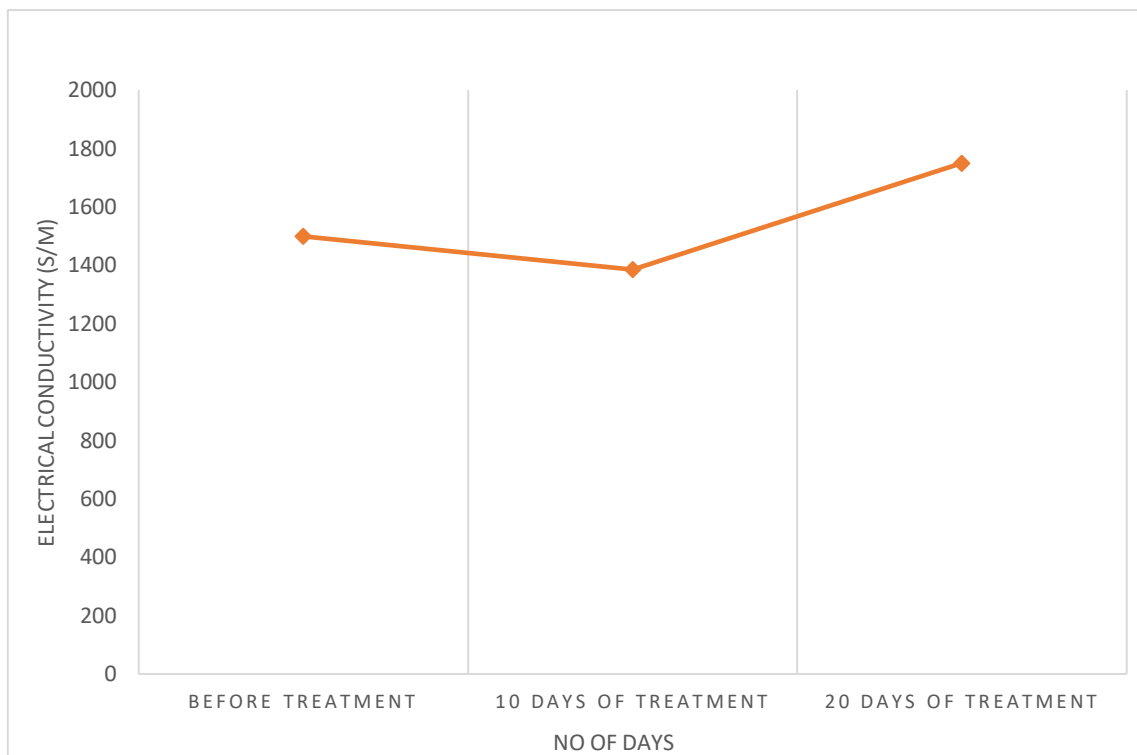


Fig 4.6 Electrical conductivity before and after treatment

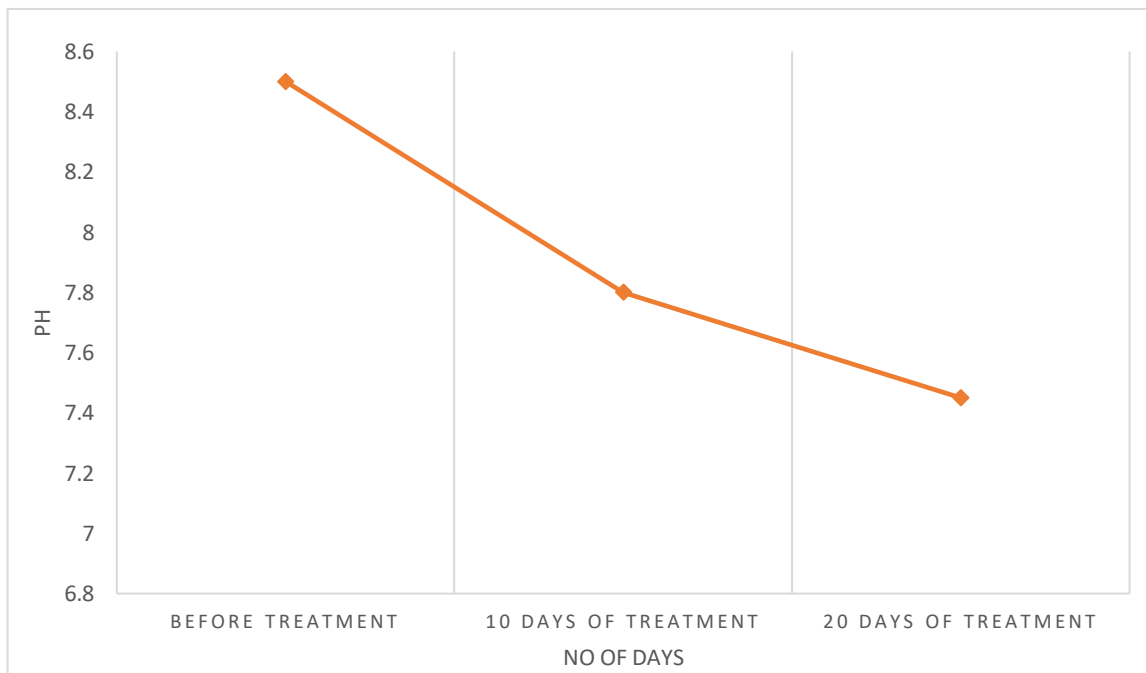


Fig 4.7 Ph before and after treatment

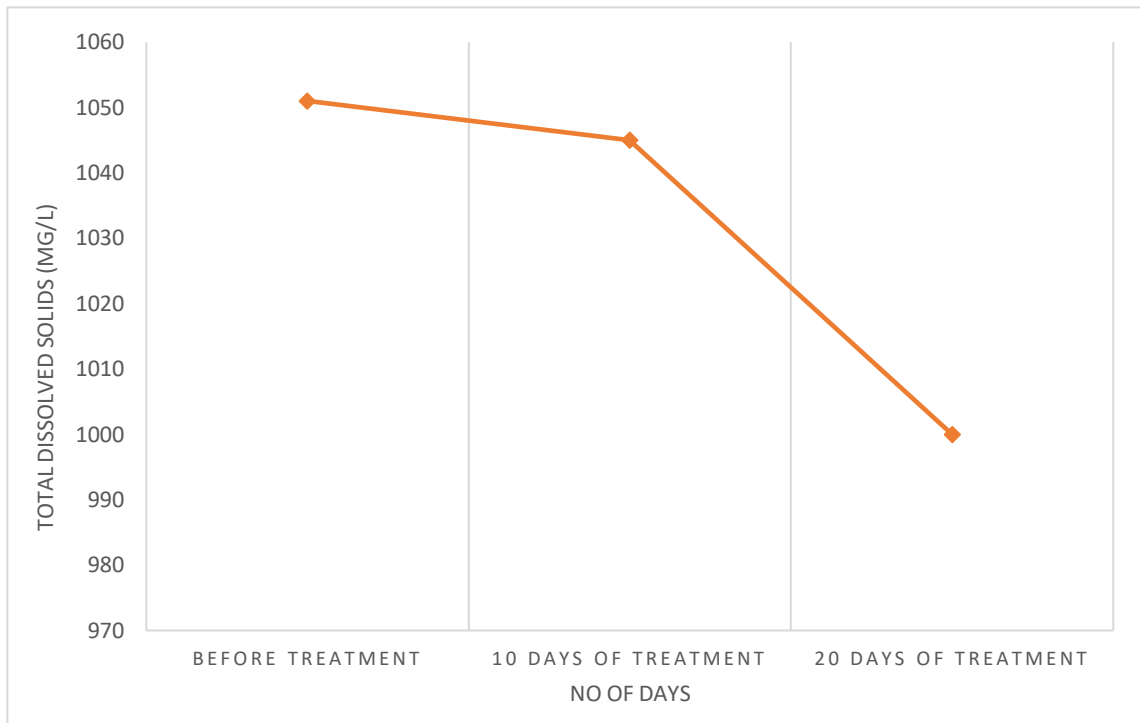


Fig 4.8 TDS before and after treatment

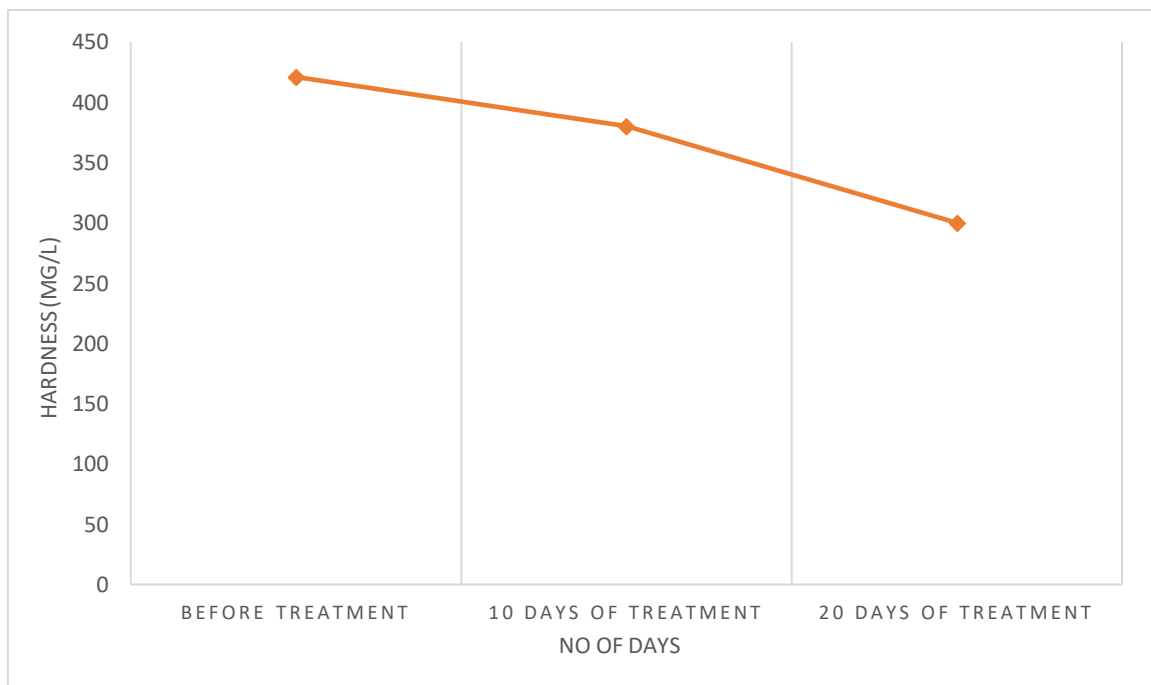


Fig 4.9 Hardness before and after treatment

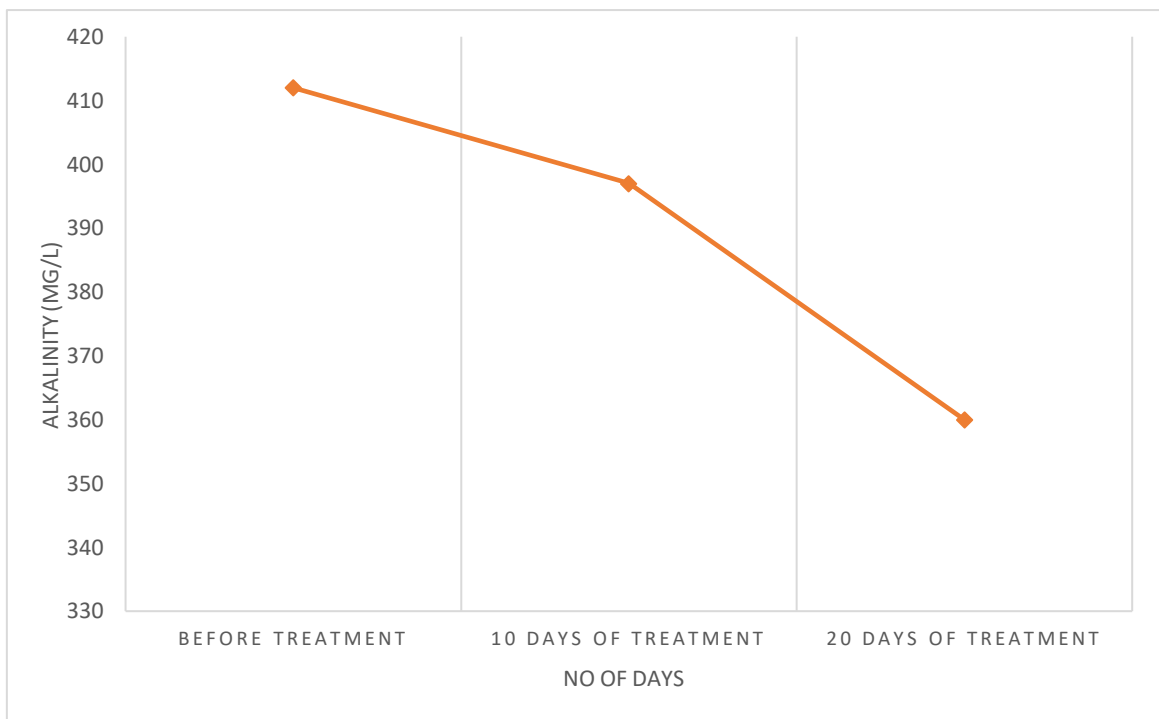


Fig 4.10 Alkalinity before and after treatment

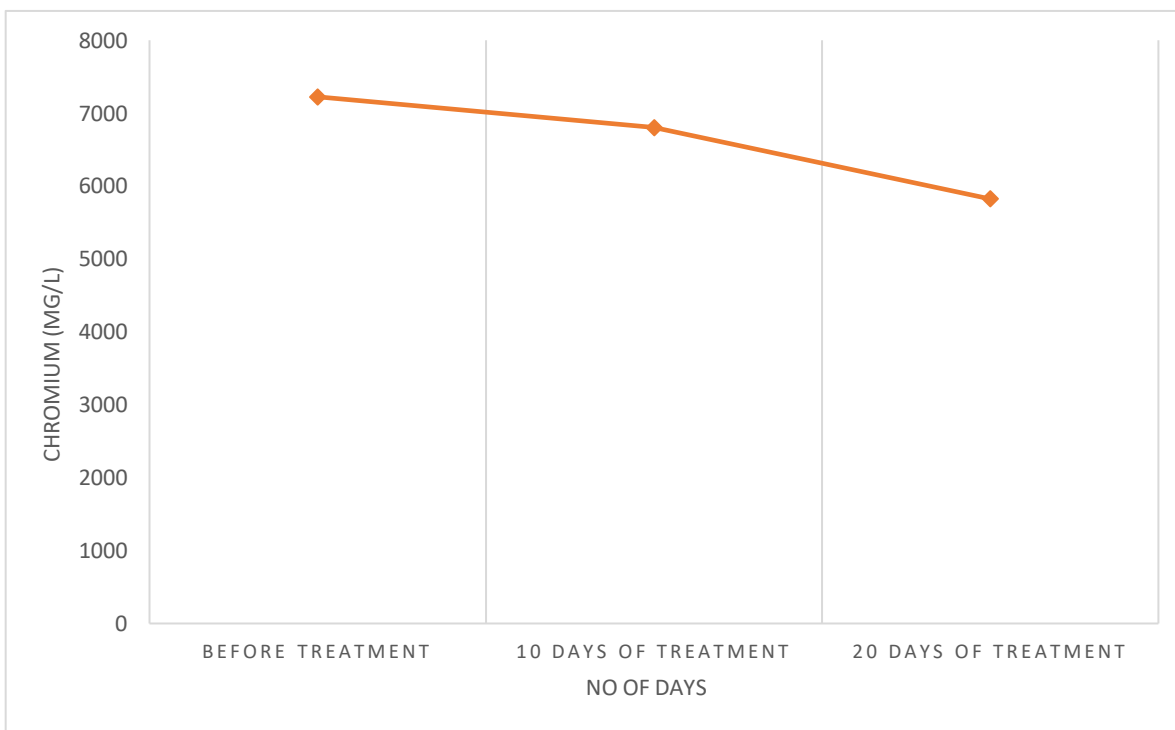


Fig 4.11 Chromium content before and after treatment

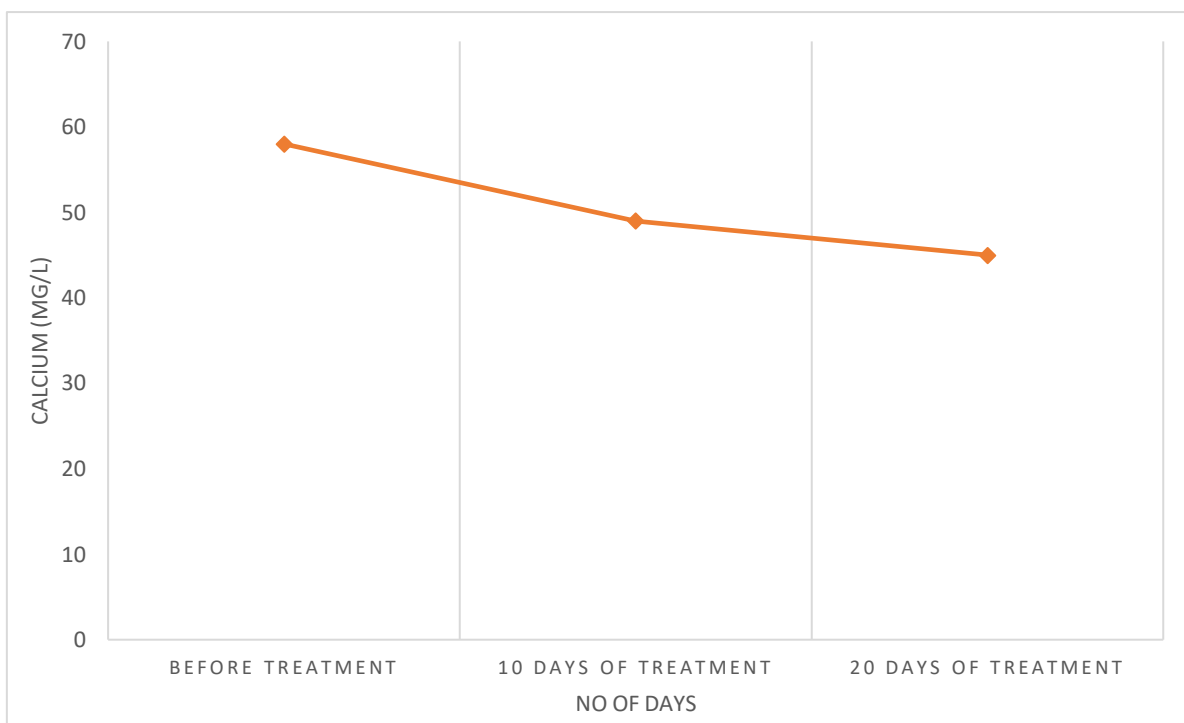


Fig 4.12 Calcium before and after treatment

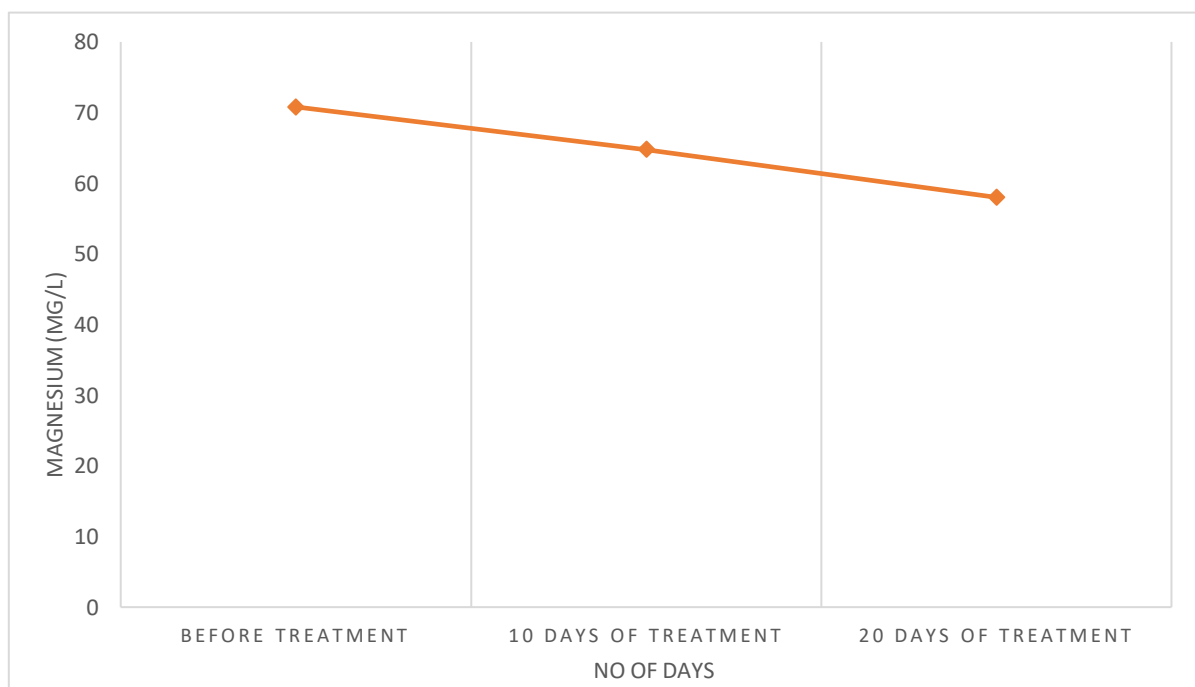


Fig 4.13 Magnesium content before and after treatment

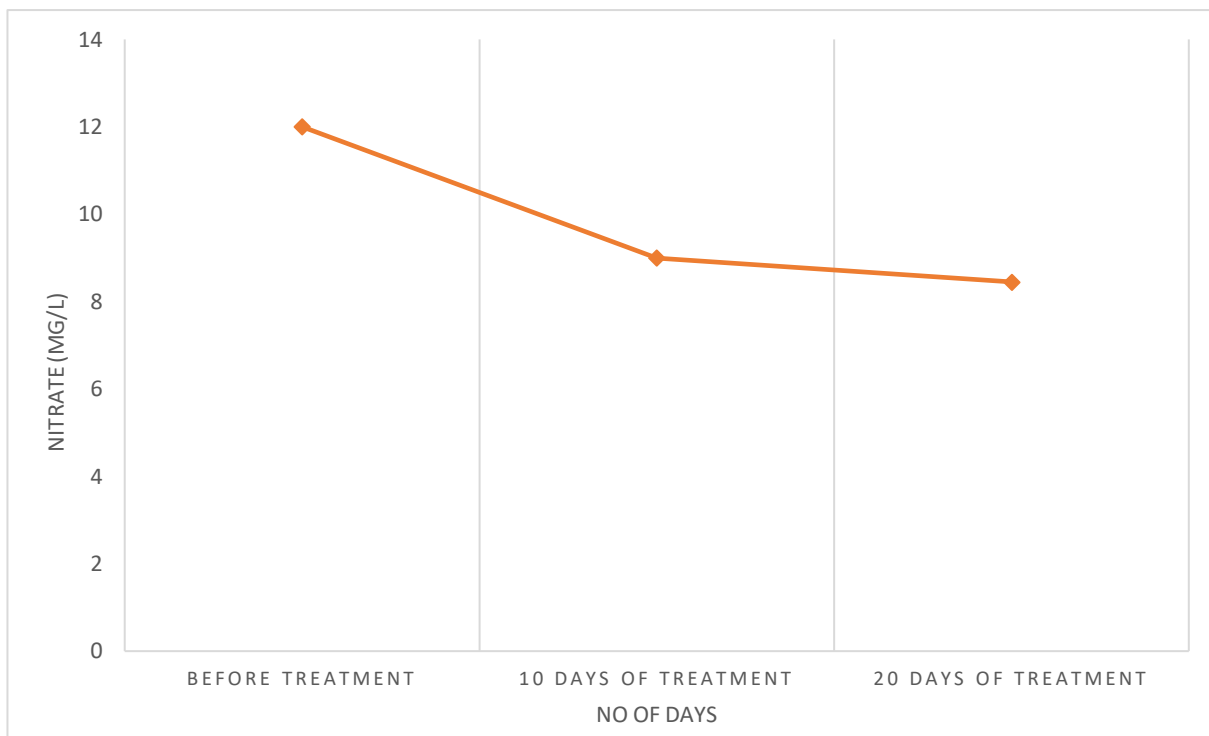


Fig 4.14 Nitrate before and after treatment

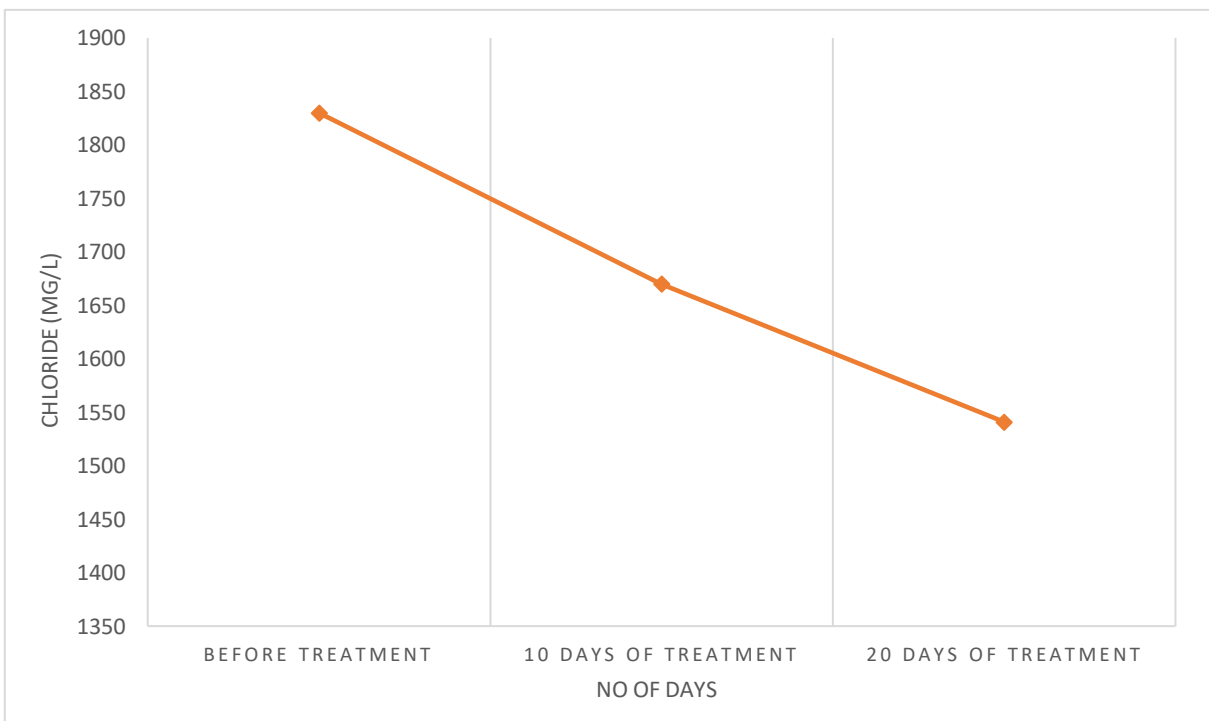


Fig 4.15 Chloride before and after treatment

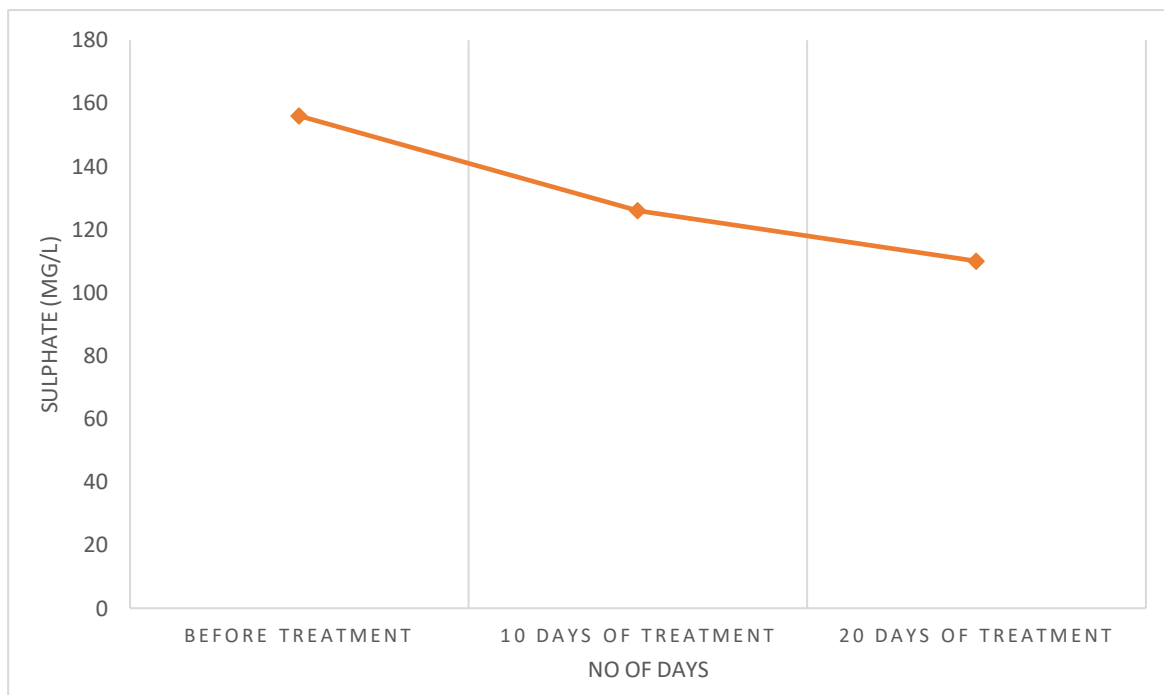


Fig 4.16 Sulphate before and after treatment

4.3 ARTIFICIAL WETLANDPOND RESULTS FOR TANNERY INDUSTRY EFFLUENT (REAL TIME TEST)

The effluent from tannery industry before treatment is shown in fig 4.14 and the effluent after 20 days of treatment by water hyacinth in the artificial pond is shown in fig 4.15. The difference between both the pictures clearly shows that the water hyacinth effectively removes the contaminants from the effluent.



Fig 4.17 Effluent before treatment

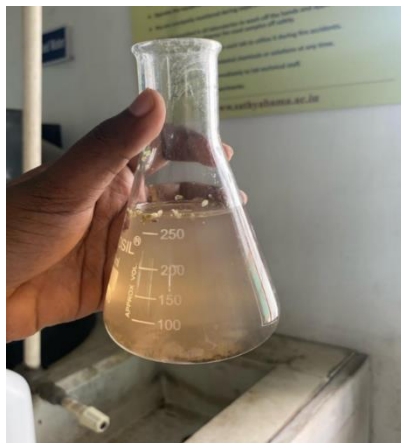


Fig 4.18 Effluent after treatment

The laboratory findings from basic physical parameters to heavy metal concentrations obtained from the analysis of tannery industry effluent in a -scale experimental setup is listed below.

Table 4.4 Physical parameter of tannery industry effluent in artificial wetland pond

Physical Parameters	Before Treatment (30.1.2024)	10 Days of Treatment (13.2.2024)	20 Days of Treatment (23.2.2024)
Appearance	Slightly Turbid	Slightly Turbid	Slightly Turbid
Colour	Dark grey in colour	Grey in colour	Yellow in colour
Odour	Unpleasant smell	Unpleasant smell	Nil

Table 4.5 Chemical parameters of tannery industry effluent in artificial wetland pond

Chemical parameters	Before treatment	10 Days of treatment	20 Days of treatment	% of reduction
Turbidity	21NTU	18 NTU	16 NTU	31.25%
Electrical conductivity	1750 s/m	1500 s/m	1410 s/m	24.1%
PH	7.9	7.4	7.2	9.72%
Total dissolved solids	2900 mg/l	2300 mg/l	2251 mg/l	28.8%
Total hardness	770 mg/l	650 mg/l	621 mg/l	24%
Total alkalinity	542 mg/l	498 mg/l	440 mg/l	23.18%
Sulphate	145 mg/l	105 mg/l	98 mg/l	47.9%
Calcium	118 mg/l	85 mg/l	75 mg/l	57.33%
Magnesium	94 mg/l	65.2 mg/l	63.3 mg/l	48.5%
Nitrate	14 mg/l	12 mg/l	12.1 mg/l	15.7%
Lead	2451 mg/l	1874 mg/l	1578 mg/l	55.36%
Chromium	8574 mg/l	7625 mg/l	6998 mg/l	22.49%

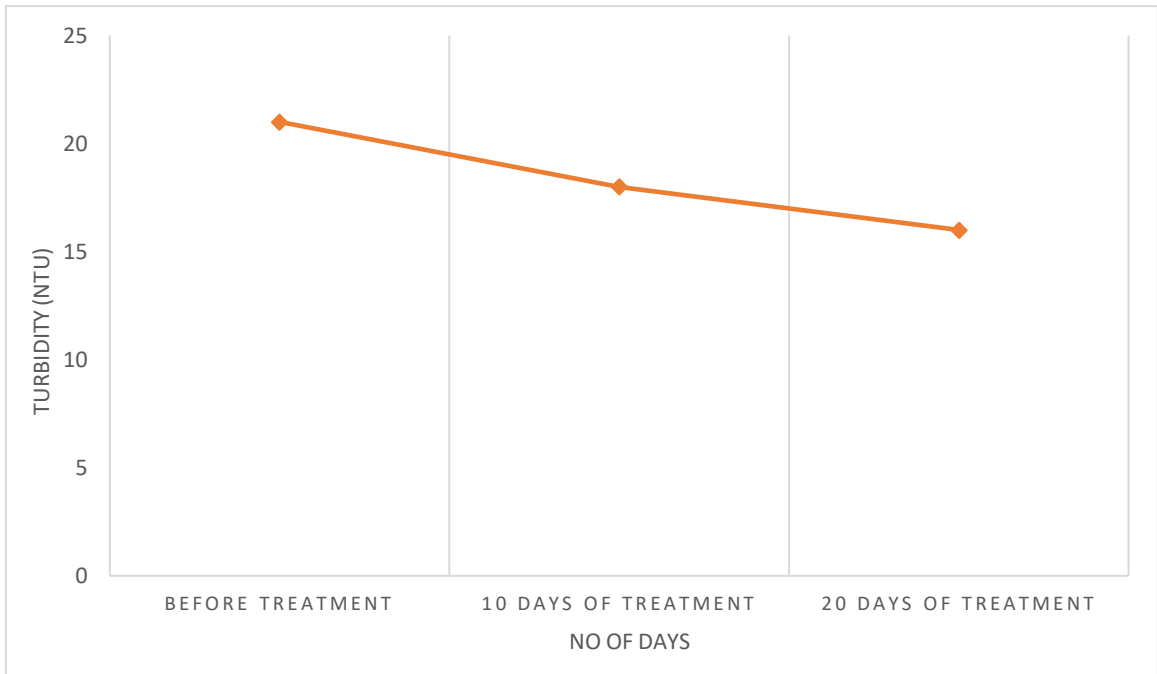


Fig 4.19 Turbidity before and after treatment

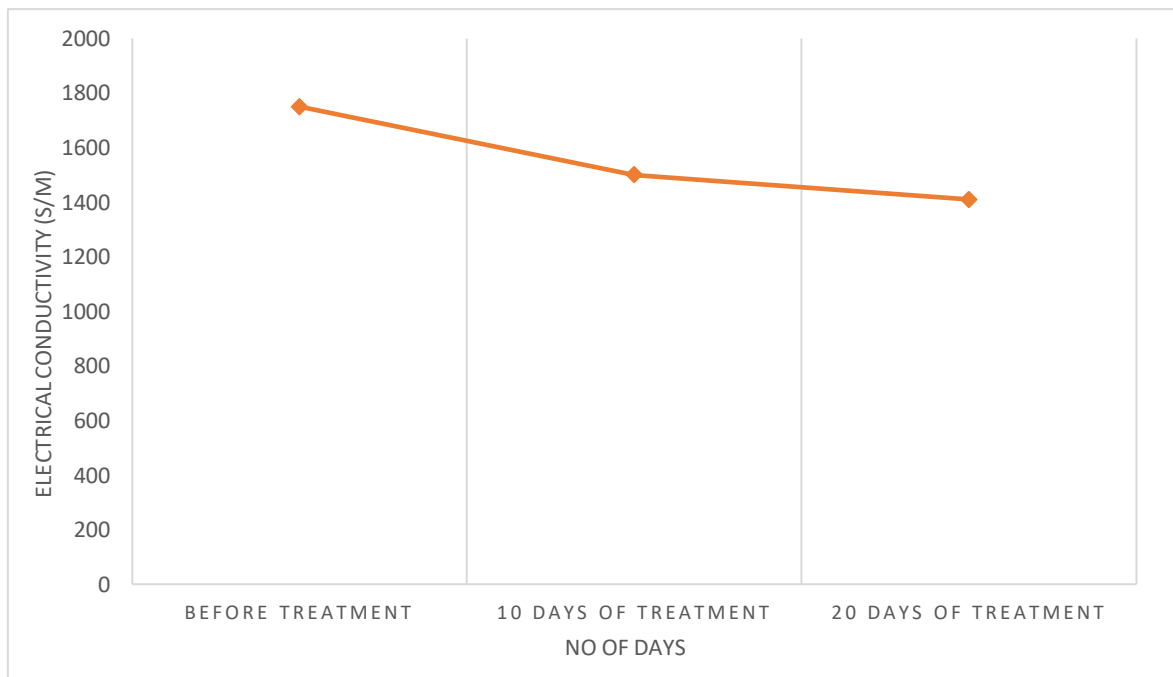


Fig 4.20 Electrical conductivity before and after treatment

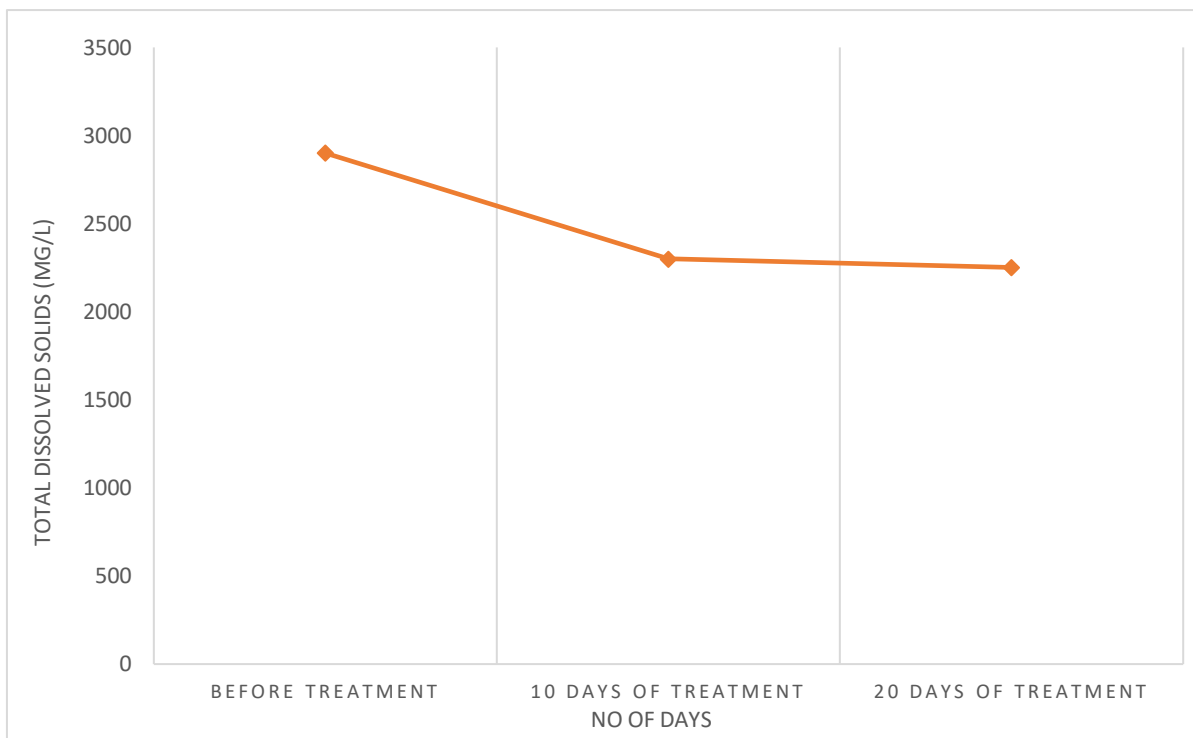


Fig 4.21 TDS before and after treatment

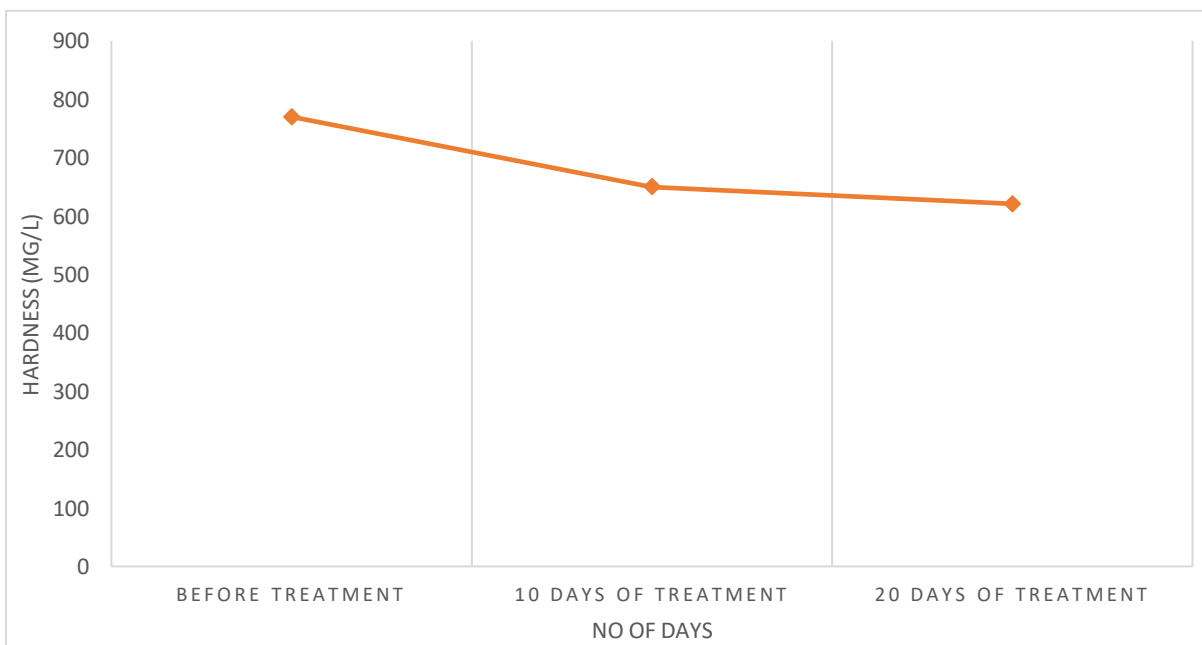


Fig 4.22 Hardness before and after treatment

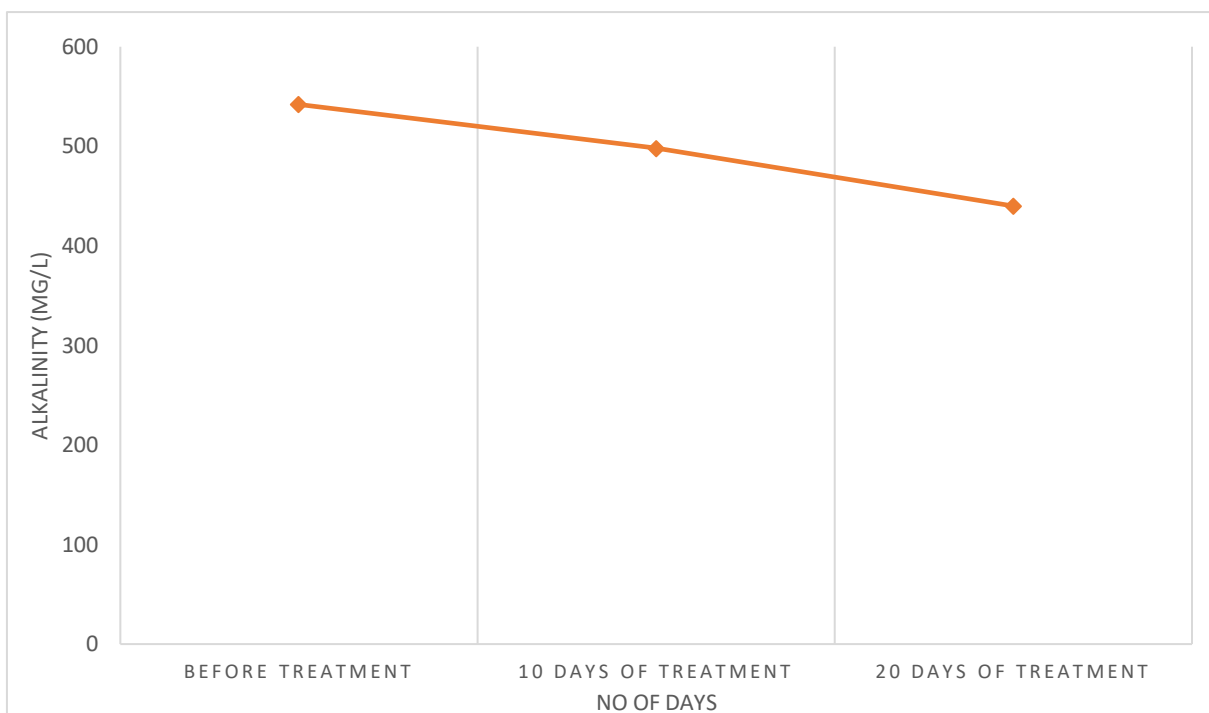


Fig 4.23 Alkalinity before and after treatment

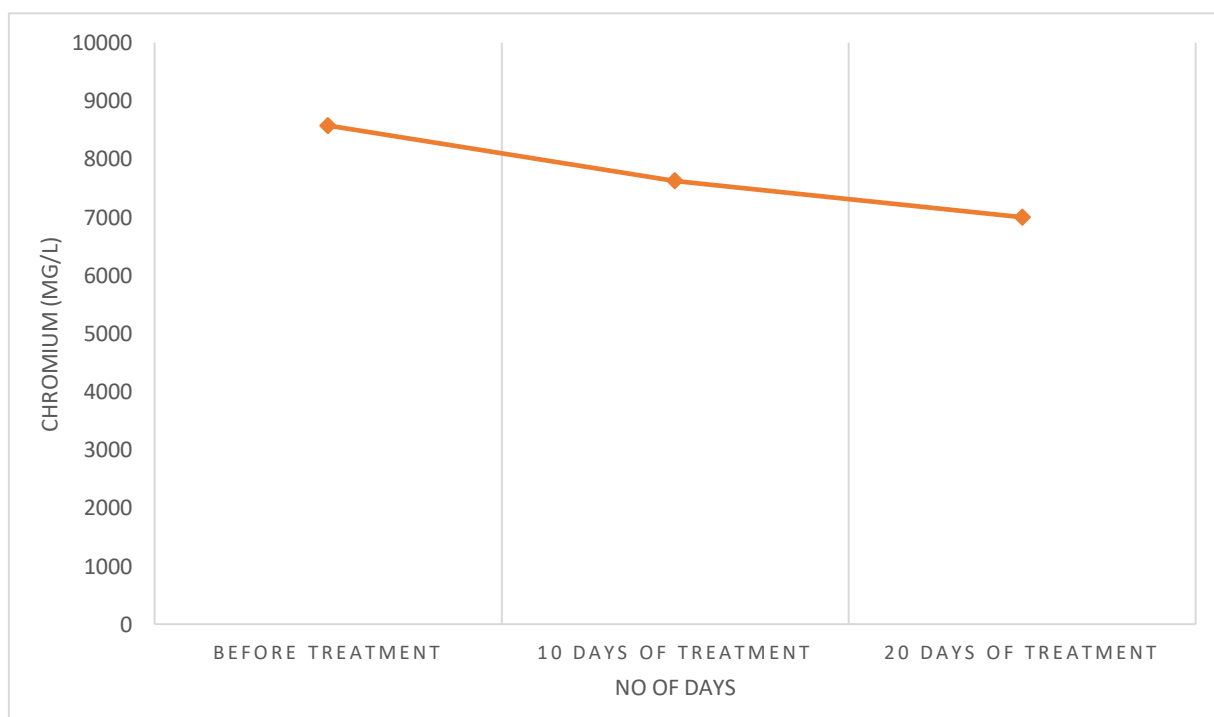


Fig 4.24 Chromium before and after treatment

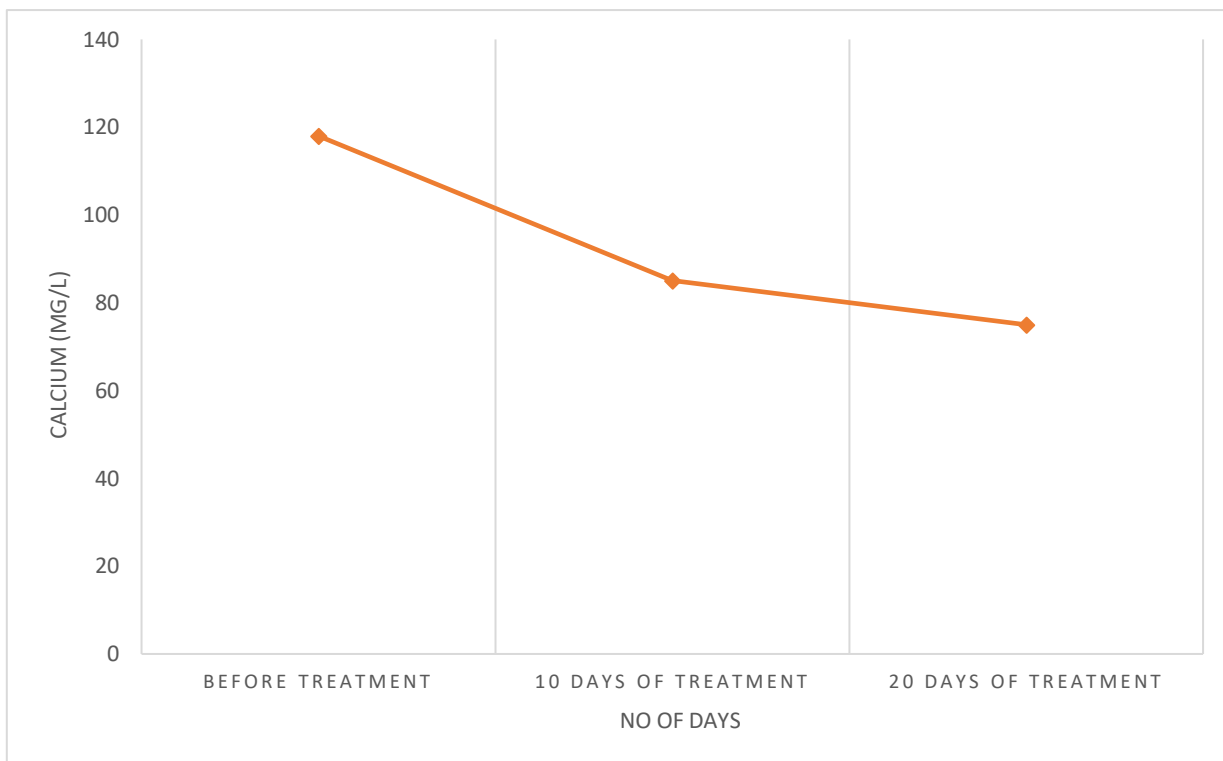


Fig 4.25 Calcium before and after treatment

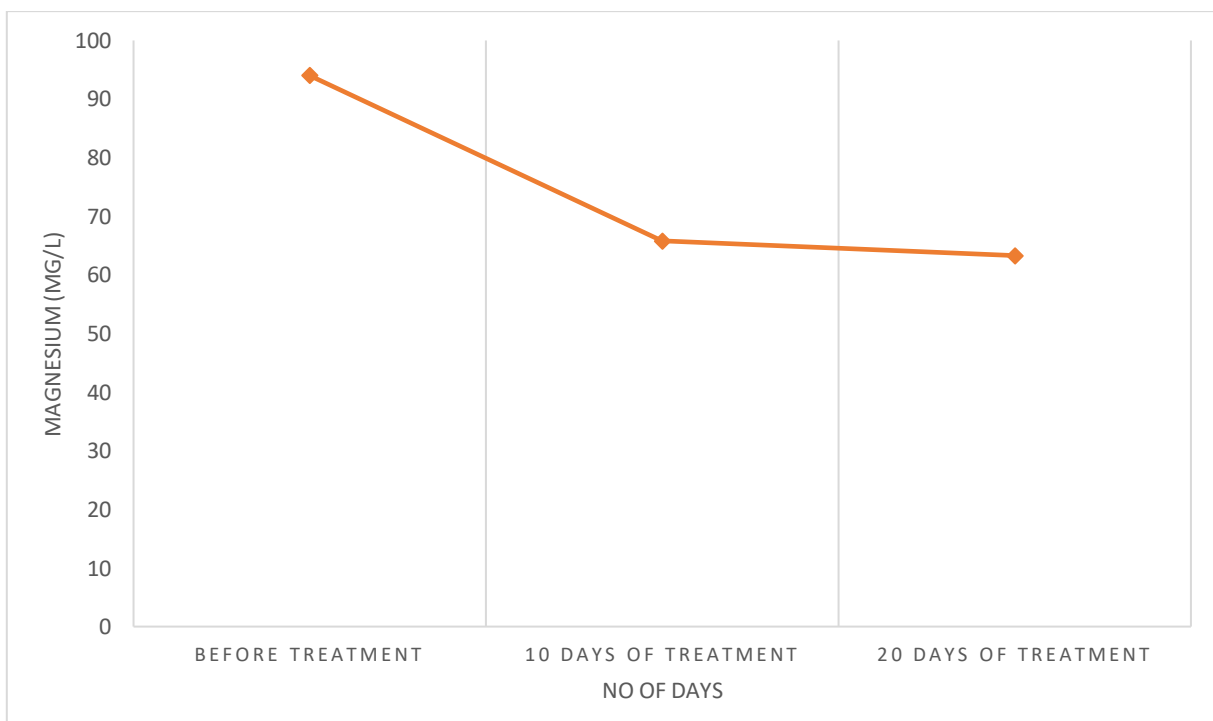


Fig 4.26 Magnesium content before and after treatment

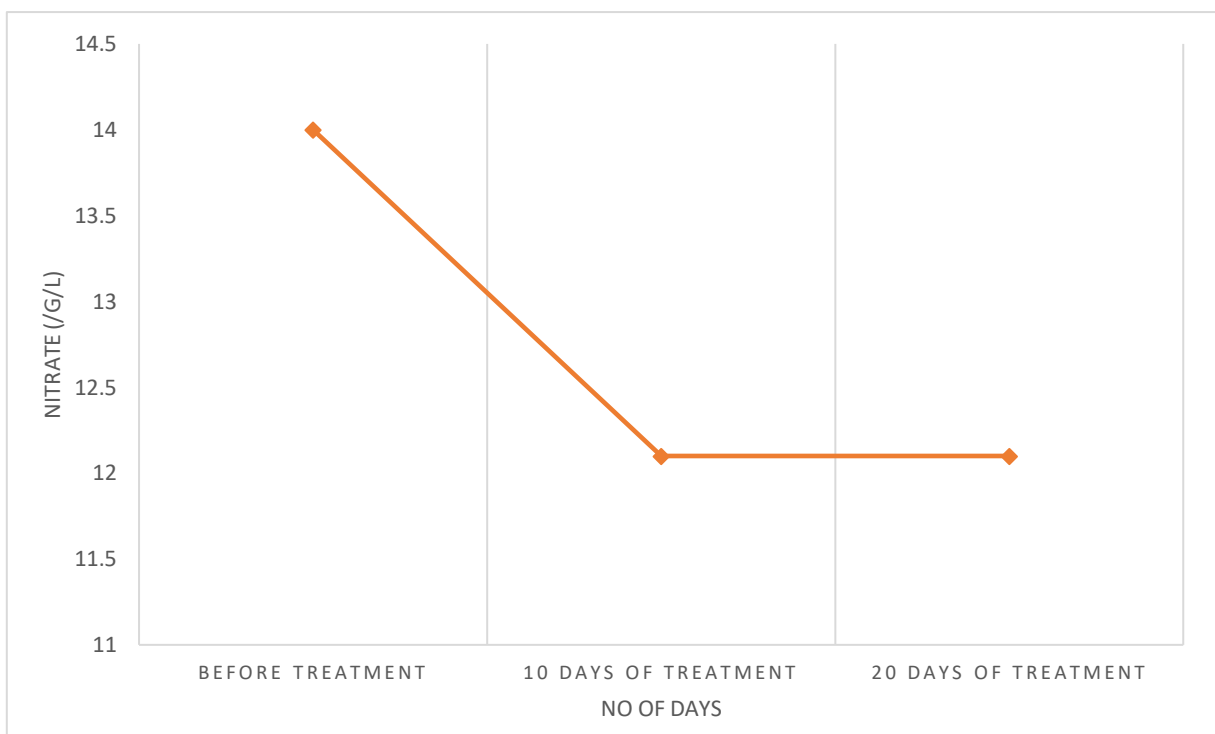


Fig 4.27 Nitrate before and after treatment

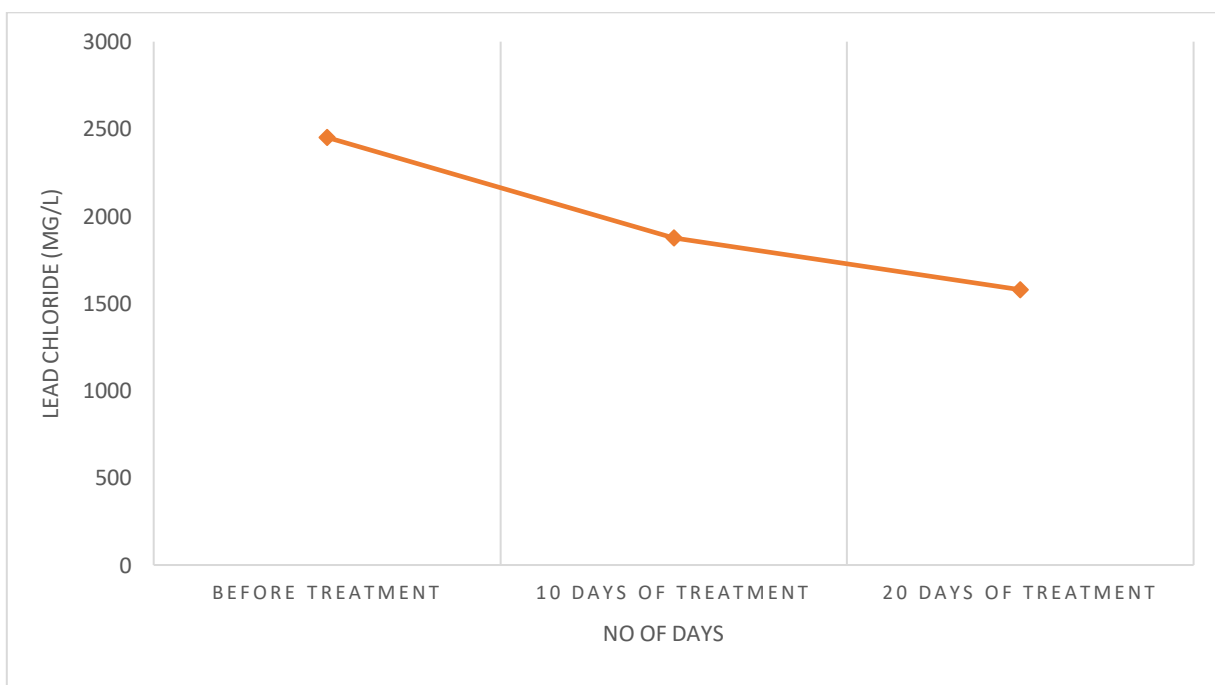


Fig 4.28 Lead chloride before and after treatment

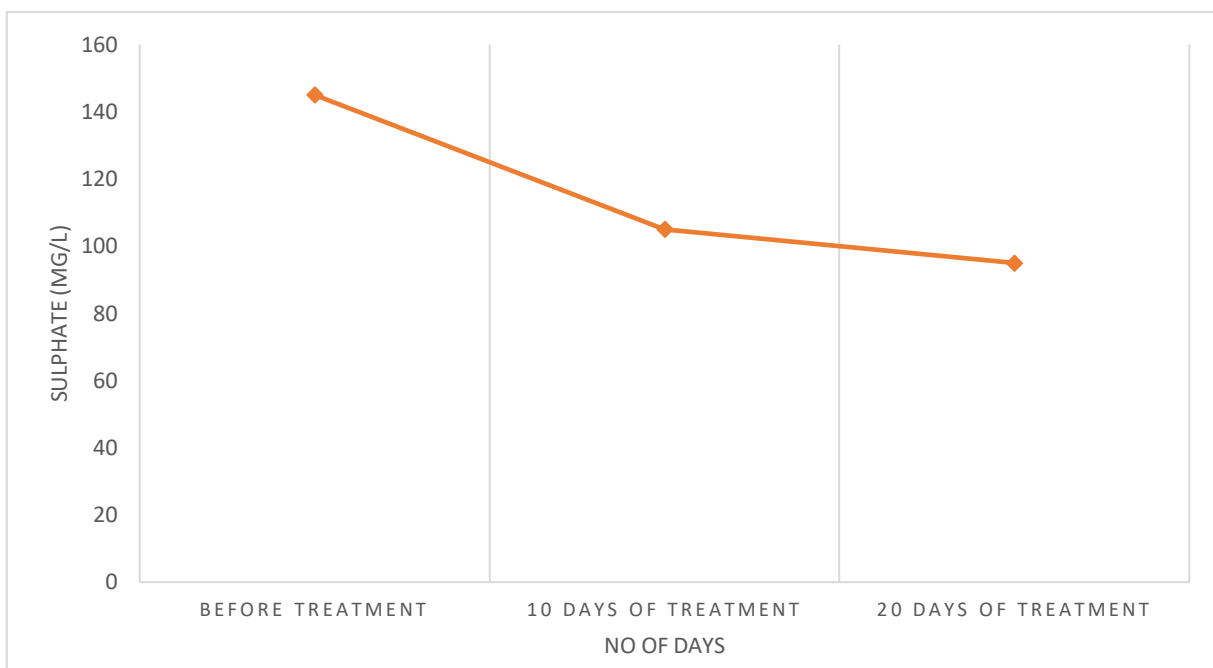


Fig 4.29 Sulphate before and after treatment

4.4 OBSERVATION OF THE PLANT

The growth rate of water hyacinth is 33 gm/week in normal water. To understand the growing ability of water hyacinth, its growth rate was studied in effluent. From the table 4.6 it can be concluded that the growth of water hyacinth decreases in effluent as the plant absorbs the heavy metals and all the other substance.

Table 4.6 Observation from Water hyacinth

Plant height Initial	Plant height after treatment	
	10 days	20 days
0.45 m	0.3 m	0.2 m

CHAPTER 5

CONCLUSION

5.1 SUMMARY OF THE STUDY

This project focused on the application of phytoremediation, specifically utilizing water hyacinth plants, to address water pollution challenges, particularly in the context of tannery industry effluent. The study area, Nagalkeni, Tamil Nadu, India, faced significant water contamination due to untreated wastewater discharge from various industries, including tanneries, leading to the presence of heavy metals and other pollutants in groundwater and surface water sources.

To assess the effectiveness of phytoremediation, a series of experiments were conducted using water hyacinth plants in artificial wetland ponds. The project scaled up from smaller tub experiments to a larger 150-liter pond, allowing for a more comprehensive treatment system. Parameters such as turbidity, pH, total dissolved solids, heavy metal concentrations, and physical appearance were monitored before and after treatment to evaluate the efficacy of the phytoremediation process.

The results demonstrated significant reductions in various pollutants, including turbidity, total dissolved solids, lead, chromium, and other heavy metals, following treatment with water hyacinth. Additionally, improvements in water appearance, colour, and odor were observed, indicating enhanced water quality post-treatment.

Overall, this project highlights the potential of phytoremediation, particularly with water hyacinth plants, as a sustainable and environmentally friendly approach to mitigate water pollution in industrial settings. By demonstrating the effectiveness of phytoremediation in real-world scenarios, this research contributes valuable insights to the field of environmental engineering and underscores the importance of integrated approaches in urban water management for safeguarding environmental and public health.

5.2 CONCLUSION

In conclusion, the significant potential of water hyacinth (*Eichhornia crassipes*) in mitigating the harmful effects of tannery industry effluent. Through both small-scale and large-scale experiments, we observed a notable decrease in various pollutants and hazardous particles present in the effluent after treatment with water hyacinth. The plant's ability to absorb heavy metals, reduce turbidity, and improve water clarity was evident from our findings. However, it's essential to note that while water hyacinth effectively cleanses the effluent, the plant's lifespan is finite, and it eventually dies off. This underscores the need for continuous monitoring and maintenance of treatment systems employing water hyacinth. The results highlight the importance of considering nature-based solutions like water hyacinth in wastewater treatment strategies, particularly in contexts where conventional treatment methods may be inadequate or costly. By harnessing the natural filtration capabilities of plants, we can achieve significant reductions in pollutant levels and enhance the overall quality of effluent discharge. Moreover, the implementation of water hyacinth-based treatment systems can contribute to sustainable water management practices and environmental conservation efforts. Moving forward, further research is warranted to optimize the efficiency and longevity of water hyacinth-based treatment systems, as well as to explore potential synergies with other treatment technologies. The application of water hyacinth resulted in a significant reduction of lead by 45% and chromium by 22%. Upon plantation in the effluent, observations revealed a reduction in plant size by 20cm, prompting an in-depth analysis of factors influencing water hyacinth health and performance.

5.3 FUTURE SCOPE OF STUDY

Our project has potential for expansion in several key areas. Firstly, we aim to scale up the Phyto-remediation process to handle larger volumes of effluent, extending our reach to address broader environmental concerns. Long-term monitoring efforts will be pivotal in evaluating the sustainability and environmental impact of our Phyto-remediation approach, providing valuable insights into its effectiveness over time and any potential repercussions on local ecosystems. To further optimize our methods, we

plan to refine the Phyto-remediation process, exploring factors such as optimal plant species selection, environmental conditions, and mechanisms for enhancing heavy metal uptake. Integrating our Phyto-remediation technique with complementary treatment methods, such as microbial or chemical remediation, will allow for more comprehensive solutions to complex water quality challenges. Community engagement initiatives will play a crucial role in fostering awareness and support, driving widespread acceptance and implementation of sustainable water treatment practices in urban areas like Nagalkeni. Additionally, ongoing research into the underlying mechanisms of Phyto-remediation processes will deepen our understanding and lay the groundwork for future innovations, ultimately leading to more effective and efficient water treatment solutions.

Reference

- [1] Ankit Gupta, Ashish Kumar Gupta, Mukesh Pandey, Ramesh Chandra - "Effectiveness of water hyacinth in the treatment of tannery effluent: A case study in India" - Journal: Ecological Engineering, Volume 108, Part A, Pages 132-139, 2017.
- [2] Ajay Kumar, Abhijeet Singh, Sudhir Kumar, Mahesh Gupta. - "Evaluation of water hyacinth for the treatment of heavy metal contaminated effluents from industries" - Journal: Journal of Environmental Management, Volume 246, Pages 417-426, 2019.
- [3] Ayesha Akhter, Tania Sharmin, Md. Mashiur Rahman, Md. Arifur Rahman - "Feasibility of water hyacinth for the phytoremediation of heavy metals in wastewater: A case study in Bangladesh" - Journal: Journal of Environmental Chemical Engineering, Volume 4, Issue 2, Part A, Pages 2036-2042, 2016.
- [4] Arjun Prasad, Rajeev Pratap Singh, Neelam Rani, Rajesh Kumar Singh - "Phytoremediation of heavy metals from tannery effluent using water hyacinth: A case study" - Journal: Journal of Environmental Management, Volume 150, Pages 63-72, 2015.
- [5] Anand Narayanan, Abhijit Sarkar, Bhagwan Das, Suresh Gupta- "Phytoremediation potential of water hyacinth (*Eichhornia crassipes*) in reducing heavy metal content from industrial effluent" - Journal: Environmental Technology & Innovation, Volume 11, Pages 305-313, 2018.
- [6] Deepika Sharma, Vandana Singh, Aparna Dixit, S.K. Garg - "Efficiency of water hyacinth in the removal of heavy metals from industrial effluents: A case study" - Journal: Desalination and Water Treatment, Volume 136, Pages 155-163, 2018.
- [7] Jyoti Yadav, Priya S., Vivek Tiwari, Ankit Gupta. - "A review on water hyacinth (*Eichhornia crassipes*) as a potential tool for phytoremediation of heavy metals"

- Journal of Environmental Science and Pollution Research, Volume 24, Issue 24, Pages 19489-19507, 2017.
- [8] Kavita Sharma, Praveen Kumar, Suresh Gupta, Deepika Sharma - "Phytoremediation potential of water hyacinth for the removal of heavy metals: A review" - Journal: Chemosphere, Volume 208, Pages 96-108, 2018.
- [9] Neelam Rani, Rajeev Pratap Singh, Ravi Kant Singh, Rajesh Kumar Singh. - "Efficiency of water hyacinth in removing heavy metals from tannery effluent: A field study" - Journal: Journal of Hazardous Materials, Volume 369, Pages 108-126, 2019.
- [10] Pradeep Kum, Rohit Kumar, B.S. Dwivedi, Nidhi Chauhanar - "Role of aquatic plants in phytoremediation of heavy metal-contaminated water: A review" - Journal: Journal of Environmental Management, Volume 235, Pages 429-438, 2019.
- [11] Praveen Kumar, Suresh Gupta, Kavita Sharma, Ankur Jain - "Phytoremediation potential of water hyacinth for removal of heavy metals from industrial effluent: A review" - Journal: Environmental Science and Pollution Research, Volume 24, Issue 11, Pages 9359-9378, 2017.
- [12] Priya S, Vinod Kumar Gupta, Vikas Kumar. - "Assessment of heavy metal accumulation in water hyacinth (*Eichhornia crassipes*) from tannery effluent" - Journal: Ecotoxicology and Environmental Safety, Volume 182, Pages 109424, 2019.
- [13] Rahul Verma, Anjali Patel, Rashmi Verma, Yogesh Kumar Tyagiet - "Role of water hyacinth in phytoremediation of heavy metal-contaminated water bodies" - Journal: Ecological Engineering, Volume 97, Pages 208-222, 2016.
- [14] Rajesh Kumar Singh and Rajesh Kumar Dubey - "Phyto-remediation of heavy metal contaminated sites using water hyacinth: A review" - Journal: Journal of Applied and Natural Science, Volume 6, Issue 1, Pages 488-495, 2014.

- [15] Renuka Pandey and Anil Kumar Singh - "Phyto-extraction of heavy metals from industrial effluents using water hyacinth" - Journal: Journal of Environmental Management, Volume 233, Pages 300-310, 2019.
- [16] Rashmi Verma, Anjali Patel, Yogesh Kumar Tyagi, Neha Rani - "Enhanced removal of heavy metals from tannery effluent using water hyacinth in constructed wetland systems" - Journal: Ecological Engineering, Volume 103, Pages 168-175, 2017.
- [17] Shikha Chandra, Prashant Singh, Vinay Kumar - "Potential of water hyacinth in removing heavy metals from aqueous solutions" - Journal: Journal of Environmental Chemical Engineering, Volume 3, Issue 3, Pages 2002-2010, 2015.
- [18] Shalini Srivastava and Mukesh Pandey - "Evaluating the efficacy of water hyacinth in the removal of heavy metals from industrial effluents" - Journal: Journal of Environmental Chemical Engineering, Volume 4, Issue 3, Pages 2783-2795, 2016.
- [19] Vivek Tiwari, Sunita Varjani, A.K. Sarma - "Bioremediation of tannery effluent using water hyacinth and its potential application in agriculture" - Journal: Ecological Engineering, Volume 112, Pages 114-121, 2018.
- [20] Vandana Singh and Shalini Srivastava - "Phytoremediation potential of water hyacinth (*Eichhornia crassipes*) for removal of heavy metals from wastewater: A review" - Journal: Ecological Engineering, Volume 97, Pages 448-467, 2016.