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Removal of Fluorides Using a Low-Cost Adsorbent

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ABSTRACT- Water is one of the most precious and important resources. We must consume safe, wholesome, and drinking water. The level of fluoride in the groundwater varies greatly among regions in India. Fluoride poisoning has reportedly gone out of hand and is currently harming at least 267 districts spread over 19 states in India, according to the Ministry of Water Resources. Thirteen districts in Andhra Pradesh have a fluoride contamination problem in eleven of them. According to IS 10500 - 2012, drinking water fluoride values must be between 1.0 mg/L and 1.5 mg/L. The Nalgonda method is one of the methods used to remove too much fluoride from groundwater. These strategies all have a variety of shortcomings. Adsorption techniques have been shown to be more efficient. ResearchersDue of their affordability and effectiveness, adsorption techniques are more frequently used by researchers.

Many natural materials and adsorbents are being tested globally. In this study, the Tulsi (Ocimum Sanctum) leaf powder was utilized as an adsorbent to remove too much fluoride from water. Because it is a medicinal plant, it won't leave any chemicals in the water that has been treated.

The study found that the highest level of fluoride removal occurs at a dosage of 0.4 g/L, which is 90.6% after three hours of interaction. Along with the initial concentration, the fluoride removal percentage increased.From the study, it can be inferred that pH value has a significant impact on the percentage of fluorides removed with Tulsi powder. High levels of fluoride removal are seen in the acidic pH range.

KEYWORDS- Fluorides, Low-cost Adsorbents, Tulsi, Percentage Removal, Adsorption.

I. INTRODUCTION

One of the most valuable and necessary resources is water. We need to drink drinkable, secure, and healthy water. Water must meet the requirement of being the least dangerous to consume in order to be safe and healthful. A water that is considered to be wholesome is often one that is unpolluted, free of poisonous compounds, as well as having an appropriate balance of minerals and organic materials.

Second only to China in terms of population is India. Despite India's rapid development, not all of its citizens have access to safe drinking water. Due to the unpredictable monsoon, erratic precipitation, and rising number of dry years, water is becoming limited in India. Since this, as a result, many residents in villages and sub-urban areas rely heavily on ground water to meet their domestic needs.

Surface water and subsurface water are very different in nature and quality. As groundwater flows through mineral deposits below ground, it picks up more minerals. Fluoride contamination is one of the most significant contaminants in ground water, especially a problem in Indian ground waters.

A. Fluoride contamination scenario of India and Andhra Pradesh

The presence of accessory minerals like fluorite and apatite in the rock mineral assemblage where the groundwater is stored, as well as environmental factors like precipitation and evaporation, are some of the factors that control the concentration of fluoride in groundwater in India. According to the Ministry of Water Resources, fluoride contamination has gotten out of control and is now affecting at least 267 districts across 19 states in India.

Eleven of Andhra Pradesh's thirteen districts have a fluoride contamination issue. All other districts, with the exception of Vijayanagram and East Godavari, have this issue, albeit Nalgonda and Anantapur are particularly affected.

B. Effects of Excess Fluorides

1) Dental and skeletal fluorosis

It is generally known that fluoride, even at very modest doses like those found in toothpaste, cannot cause the type of skeletal fluorosis that is currently prevalent in India. It has been determined that a daily intake of up to 10–20 mg for adults and 3–8 mg for kids is detrimental. These values have been used to determine the rough water safety standards for India, which are 1 mg/l and 1.5 mg/l, respectively.

2) Skeletal fluorosis of legs

Fluorosis comes in two primary varieties: skeletal fluorosis and dental fluorosis. Continuous exposure to high fluoride concentrations during tooth development results in dental fluorosis, which results in enamel with a low mineral content and increased porosity. Between the ages of 1 and 4 is when dental fluorosis risk is at its highest. the time after age 8 Once permanent teeth have erupted, the risk of dental fluorosis is reduced.

When calcium metabolism is disturbed during the body's bone-forming process, skeletal fluorosis results. It causes the bones to become softer and weaker, which results in abnormalities and eventual paralysis. Additionally, it can exacerbate diseases linked to calcium, primarily osteoporosis in adults and rickets in youngsters. Severe occurrences of crippling can happen for persons who are exposed to excessive fluoride levels for several years.

- More than 60 million people likely drink water with a fluoride content of more than 1 mg/l in 20 states of India, more than 100 districts nationwide, and other parts of the world. Food contains fluoride in these areas because it can be used to irrigate local produce. This increases the amount of fluoride consumed daily to more than 10 mg/day, which is always detrimental for both adults and children.The initial start comes from straightforward detection. This can be achieved by doing a straightforward, suggestive field fluoride test on water and checking the children's teeth for staining. For instance, the majority of us are unaware of how easy it is to quickly test for fluoride using for instance, the majority of us are unaware of how easy it is to quickly test for fluoride using a field kit, which only costs a few rupees each time. Imagining even such a tiny expenditure could prevent you from developing fluorosis. Undoubtedly, there are instruments with greater complexity, such an Ion. This has a more precise electrode for measuring fluoride. It is also feasible to test for fluoride in blood and urine, although there aren't many labs in the US that do that at the moment.

3) Removal of fluoride from water

- Fluoride excess in ground water is removed using a variety of techniques. The Nalgonda approach, using activated alumina, the ion exchange process, and the reverse osmosis process are a few of the most often utilized techniques. All of these techniques have a number of drawbacks, including high costs, ineffective removal, inefficient regeneration, and chemical contamination of treated water.
- Recently, there have been a lot of research projects looking for a quick and effective way to remove excess fluorides from ground water. Researchers are more likely to use adsorption techniques. Even while expensive adsorbents like activated carbon are expensive, numerous inexpensive materials can also work quite well as adsorbents. These adsorbents are also less expensive.

4) Present study and Objectives

Around the world, numerous natural adsorbents and materials are being tested. Tulasi (Ocimum Sanctum) leaf powder is used in the current investigation as an adsorbent to remove excess fluorides from water.Tulsi powder, which comes from a medicinal plant, makes treated water safe to drink by removing any remaining contaminants.

- The purpose of the current study is to:
- 1. Determine whether Tulsi leaf powder is effective as a fluoride adsorbent.
- 2. To evaluate its effectiveness using different dosages, fluoride starting concentrations, and pH levels.

II. LITERATURE REVIEW

Due to its high reactivity, fluorine, a common element, does not exist in nature in its elemental form. It is present in the form of fluorides in several minerals, the most prevalent of which are fluorspar, cryolite, and Fluor apatite, and makes up around 0.3 g/kg of the Earth's crust. The fluoride ion is in the -1st stage of oxidation.

A. Physiochemical properties

The boiling point of hydrogen fluoride (HF), an odorless, unpleasant liquid or gas, is 19.5 °C. It generates hydrofluoric acid in water because of its high solubility. Colorless to white solid sodium fluoride (NaF; CAS No. 7681-49-4) is only weakly soluble in water. Hexa-fluoro-silicic acid, often known as fluoro-silicic acid, is a colorless solid that is very soluble in water (CAS No. 16961-83-4, H_2SiF_6).

B. Major uses

There are many industrial uses for inorganic fluorine compounds. They serve as a flux in the steel and glass fiber industries and are utilized in the manufacturing of aluminum. They may also be released into the environment during the manufacture of bricks, tiles, and ceramics as well as phosphate fertilizers, which typically include 3.8% fluorine. Municipal water fluoridation programs use sodium fluoride, sodium hexafluoro silicate, and fluorosilicic acid (IARC, 1982; IPCS, 2002).

C. Analytical Methods

Fluoride concentrations are often measured using an ion-selective electrode, which allows for the measurement of both free and complex-bound fluoride concentrations in the water. The technique is applicable to water with a minimum concentration of 20 g/liter (Slooff et al., 1988). A detection limit of 1 g/liter was found for rainwater containing fluoride at a concentration of 10 g/liter (Barnard & Nordstrom, 1982). A technique to measure fluoride at concentrations of 0.05–0.4 mg/liter has been reported (Liu et al., 1987) utilizing an ion analyzer and a fluoride-selective electrode.

D. Environmental Levels & Human Exposure Water

Many rivers contain trace amounts of fluoride; greater concentrations are frequently linked to subterranean sources. According to Slooff et al. (1988), there is 1.3 mg/liter of total fluoride in saltwater. Well water in regions with a lot of fluoride-containing minerals may have up to 10 milligrams of fluoride per liter. The highest known natural concentration is 2800 mg/liter. Industrial discharges may potentially cause fluorides to reach a river (Slooff et al., 1988). Fluoride concentrations in groundwater vary depending on the type of rock the water passes through, although they typically do not go above 10 mg/liter (US EPA, 1985a). The Netherlands' Rhine has levels that are less than 0.2 mg/liter. Industrial processes cause concentrations in the Meuse to fluctuate (0.2–1.3

mg/liter) (Slooff et al. Due to industrial operations, concentrations in the Meuse vary (0.2–1.3 mg/liter) (Slooff et al., 1988). Some Chinese villages had groundwater with fluoride contents more than 8 mg/liter (Fuhong & Shuqin, 1988; Anonymous, 1990). In Canada, municipal waters have been found to contain fluoride levels between 0.05 and 0.2 mg/liter (non-fluoridated) and 0.6 and 1.1 mg/liter (fluoridated); amounts as high as 3.3 mg/liter have been found in drinking water made from well water. According to the US EPA (1985a), 0.2% of Americans are exposed to levels more than 2.0 mg/liter. All drinking-water plants in the Netherlands have annual averages below 0.2 mg/liter (Slooff et al., 1988). Fluoride levels in drinking water can be extremely high in some African nations where the soil is rich in fluoride-containing minerals (e.g., 8 Fluoride levels in drinking water can be extremely high in some African nations where the soil is rich in minerals that contain fluoride (e.g., 8 mg/liter in the United Republic of Tanzania) (US EPA, 1985a).

A thorough analysis of groundwater boreholes in central Australia revealed that fluoride levels in half of the supplies were higher than 1.5 mg/liter, with several of them lying between 3 and 9 mg/liter (Fitzgerald et al., 2000).

E. Estimated total exposure and relative contribution of drinking-water

Fluoride exposure levels vary greatly depending on where you live. Fluoride intake on a daily basis in the Netherlands is estimated to be between 1.4 and 6.0 mg. 80–85% of fluoride intake appears to come from food; consumption from drinking water is 0.03-0.68 mg/day and from toothpaste is 0.2–0.3 mg/day. Due to lesser consumption, children's total intake of food and water is reduced. However, consumption of food and liquids is higher in relation to body weight and can be further boosted by ingesting fluoride tablets or toothpaste (up to 3.5 mg of fluoride per day) (Slooff et al., 1988).

F. Removal of Fluorides from Water Using Low-Cost Adsorbents by P.D. Nemadeand A. Vasudevarao

Since it causes FLUOROSIS, a condition that affects teeth and bones, there has been a lot of attention paid to the issue of excessive fluorides in drinking water. This issue is one that is of great concern throughout the world. Fluoride's hazardous effects have prompted extensive study into ways to eliminate it from drinking water.

The scientific literature on the various facets of fluorine chemistry, its occurrence, distribution, and utilization of inexpensive adsorbents is reviewed in this work. The efficacy of removing fluoride from fly ash, brick powder, wood charcoal, animal bone charcoal, and fish bone charcoal was investigated in batch adsorption tests.

The impacts of several factors, including contact time, pH, adsorbent dosage, and adsorbate concentration on the removal efficiency, were examined in this study. We discovered how contact time affected the effectiveness of adsorbents in removing fluoride. He came to the conclusion that the majority of the removal could be acquired in the first two hours and that there would be little to no removal if the contact time was extended.

G. Removal of Fluoride from Water and Wastewater by using Low-Cost Adsorbents by N. Gandhi and D. Sirisha

(Jawaharlal Nehru Technological University-Anantapur): Fluoride in ground water that exceeds recommended limits (0.6-1.5 mg/L) is a significant issue in many regions of the world. The current study is being conducted to investigate efficient and affordable adsorbents for the removal of fluoride from the water, taking into account the severity of the issue.

This report reviews the main states in India that are affected by dental and skeletal fluorosis as a result of elevated fluoride levels in groundwater. Andhra Pradesh, Telangana, Rajasthan, Gujarat, Uttar Pradesh, and Tamil Nadu are some of the well-known states that are seriously impacted.

Studies on batch adsorption are conducted. Several inexpensive adsorbents, including concrete, ragi seed powder, red dirt, horse gram seed powder, orange peel powder, chalk powder, and pine apples were used in the laboratory studies. On a variety of inexpensive adsorbents, including concrete, ragi seed powder, red dirt, horse gram seed powder, orange peel powder, chalk powder, pine apple peel powder, and multhanimatti, studies were carried out in a lab setting.

He came to the conclusion that at lower concentrations than at higher concentrations, adsorption capability is lower. Physical adsorption is seen to occur.

The effectiveness of the adsorbents was determined based on the impact of contact time, concentration, adsorbent dosage, and temperature.

- Depending on the concentration of fluoride, the ideal contact time for fluoride elimination is between 20 and 30 minutes.
- As contact time goes on, fluoride's capacity for adsorption grows. When saturation point is reached, the fluoride content cannot be removed. Various adsorbents have various contact times. It is dependent on various adsorbents have various contact times. It relies on the adsorbents' characteristics.
- The percentage of fluoride removed reduces as the original fluoride concentration rises.
- The proportion of fluoride removal increases to some extent when adsorbent dosage rises. The removal of the fluoride content won't change after it reaches saturation stage.

H. Defluoridation of Contaminated Water by using Low-Cost Adsorbents by Kavitha Panchore, Dr. Saritha Sharma

(Ujjain Engineering College): When compared based on initial cost, flexibility and simplicity of design, ease of operation and maintenance, and efficacy for fluoride removal in drinking water, the authors identified adsorption as one of the most effective technologies.

The article gives an overview of different inexpensive adsorbents that can be used in place of pricey commercial adsorbents to remove fluoride from water effectively. Numerous factors, including pH, adsorbent dose, surface area, contact time, temperature, and beginning fluoride concentration, affect how effective various adsorbents are. By raising the adsorbent dosage and reducing particle size, the removal capacity rises.

III. REMOVAL TECHNIQUES AND ADSORPTION

There are numerous ways to remove fluorides from water and wastewater. Each technique has pros and cons of its own. This chapter discusses a few of the most popular fluoride removal techniques. Each method's benefits and drawbacks are listed. Adsorption method is given particular attention.

A. Fluoride Removal Techniques

There are numerous ways to eliminate fluorides from water. The following are a few methods that are frequently employed to remove fluoride.

- Ion exchange 1.
- The Nalgonda Method
- Electro dialysis and reverse osmosis
- Active Aluminium Oxide
- Charred bones 6. Organic adsorbents

B. Ion Exchange Method

A strongly fundamental anion exchange resin with quaternary ammonium functional groups can remove fluorides from water supplies. The removal occurs in accordance with the following response.
Matrix -NR3 +F + Cl + Matrix -NR3 +Cl + F
The resin's chloride ions are replaced by fluoride ions. This procedure continues until all of the resin's spots are occupied. The resin is then backwashed with water that has sodium chloride salt supersaturated in it. The fluoride ions are subsequently replaced by new chloride ions, causing the resin to recharge and the process to start over.

C. Advantages

• High output (removal of 90–95 percent of fluoride)
• Preserves water's superiority

D. Disadvantages

- Technique is quite expensive.
- The pH of treated water is low and the fluoride content is high.
- Resin regeneration is problematic because it produces fluoride-rich water, which must be dealt with before final disposal.
- It necessitates a longer reaction time

1) 'NALGONDA' Technique

The "NALGONDA TECHNIQUE" is a cost-effective and straightforward fluoride removal technique developed by the National Environmental Engineering Research Institute in Nagpur.The steps in the procedure are flocculation, sedimentation, and filtration after adding alum, lime, and bleaching powder to fluoride water in that order.The method is very helpful for both home and communal water supplies**.**

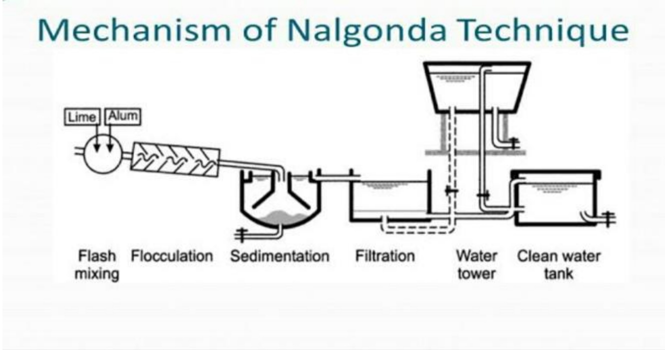

Figure 1: Nalgonda Technique for the removal of fluorides

2) Advantages

1. Media regeneration is not necessary.
2. Avoid touching alkalis and caustic acids.
3. Cost-effectiveness, ease of design, construction, use, and upkeep.

3) Disadvantages

1. When the total dissolved solids exceed 1500 mg/L, desalination is required.
2. How much alum is required to eliminate fluoride.
3. The pH of treated water must be carefully regulated.

4) Requirements for the adoption of Nalgonda technique

1. Lack of a suitable alternative low-fluoride supply nearby.
2. Total dissolved solids less than 1500 mg/L.
3. The total hardness is less than 600 mg/L.
4. Fluorides in raw water that range from 1.5 to 20 mg/L.

5) Reverse Osmosis and Electrodialysis:

The physical processes of reverse osmosis, electrolysis, and electrodialysis are investigated for defluoridation of water.Despite being efficient at removing fluoride salts from water, they have a few drawbacks that prevent widespread use.

6) Advantages

1. Does not need chemical addition.
2. Pre- and post-treatments are not necessary.
3. A small amount of muck.
Activated Alumina Use
It has been discovered that eliminating fluoride from water by filtering it through a bed of activated alumina is particularly effective.
The disadvantages with activated alumina are:
1. Specific pH range
2. Needing pre and post- pH adjustment of water
3. Frequent activation of alumina is needed, which make the technique expensive.

7) Use of Bone char

For the purpose of removing fluoride from water, bone char can be employed as an adsorbent or as an ion exchange bed.The temperature, pH, and length of time that the bone char spends in contact with the raw water all affect the plant's efficiency.It is a very cost-effective technology with a 62–66% defluoridation percentage

8) Disadvantage

1.Thebonechar harbours bacteria and hence unhygienic.
2. It is a technique sensitive procedure.
3. The use of bone char may also invite religious and cultural objections.

9) Use of Natural adsorbents

- Many natural adsorbents from various trees were tried as natural adsorbents.
- Seeds of the drumstick tree, roots of vetiver grass and Tamarindseeds were few among them.
- Researchers at "M.S. Swaminathan Research Foundation"(MSSRF) had shown drumstick seeds to have higher and remarkable defluoridation efficiency, which was higher than that of activated alumina.

10) Adsorption

Adsorption is the process, similar to adsorption, by which a substance in a gas or liquid becomes attached to a solid. Thematerial could be an adsorbate, a contaminant adhering to the surface of a certain solid. Although adsorption happens naturally, businessmen have developed a method to clean up hazardous trash or purify drinking water using adsorption.

Adsorption must be distinguished from adsorption, which is the filling of pores in a solid. Adsorption is the binding of molecules or particles to a surface. The binding to a surface is often reversible and weak. The fluid that dissolves or suspends the substances of interest is also bound, as is just about anything else, but substances with color and those with flavors or odors have a tendency to bond more firmly. On activated carbon, chromogenic compounds—atom configurations that vibrate at frequencies in the visible spectrum—are frequently heavily adsorbed. Decolorization can be incredibly effective when done byBy using adsorption, decolorization is remarkably effective with little loss of other components.

Activated carbon is the most often used adsorbent in industry. silica gel and alumina because of their high surface area to weight ratios.

Coconut shells, wood, and animal bones are typical sources of activated carbon and are made by roasting organic material to break it down into carbon granules. A matrix of hydrated silicon dioxide is called silica gel. Aluminum oxide and hydroxide are mined or precipitated to produce alumina. Even though activated carbon is an adsorption material

11) Mechanism of Adsorption

Materials are removed from solutions by porous adsorbents in three phases that follow one another.

- The movement of the adsorbate out of the adsorbent and across a surface layer
- Sorption by adsorbents with pores
- Adsorption of the solute on the surface inside the adsorbent that surrounds the pore and capillary space.
- Factors Influencing Adsorption

12) Surface area

Adsorption is inversely correlated with specific area. The percentage of the total that is open to adsorption can be referred to as specific.Nature of the adsorbent

The solute's solubility in the solvent has an inverse relationship with the solute's adsorption. According to Lundelius' rule, the stronger the solute-solvent bond is, the less adsorption there is

13) pH

The pH of the solution affects the adsorption of other ions because hydrogen and hydroxide ions are very heavily adsorbed. In general, a fall in pH increases the adsorption of common organic pollutants from water.

The extent of adsorption often increases with decreasing temperature since the temperature adsorption reaction is typically exothermic.

14) mixed solutes' adsorption

According to the respective sizes of the molecules being adsorbed, the relative adsorptive affinities, and the relative concentration of the solutes, the degree of mutual inhabitation of competing adsorbate should be determined.

IV. MATERIALS AND METHODOLOGY

The previous chapter gave a thorough overview of adsorption from several angles. This chapter contains a detailed discussion of the experimental approach used to remove fluorine using an adsorption procedure.

A. Materials

A wide variety of materials are being tested, as are numerous natural adsorbents. The Tulsi (Ocimum Sanctum) leaf powder used in this study is chosen as an adsorbent to remove excess fluorides from water. It won't leave any chemicals in the treated water because it is a therapeutic plant.

B. How to make tulsi powder

The Tulsi or basil leaves are gathered, carefully cleaned, and then left to dry for two to three days without exposure to sunlight. The leaves are ground into a fine powder and used as an adsorbent after that.

C. Methodology

The methods used for this investigation is divided into two sections. Phase 1 of the study examines the qualities and preparation of the material. It also covers the experimental variables, such as contact time, dosage, etc., that have an impact on the adsorption processes.

D. Adsorption Research

In this study, batch studies are used, and the following parameters are taken into account.
dose of the absorbent
3. Contact time 2. pH
4. The initial concentration of fluoride

E. Determination of Fluorides by Zirconium Alizarin Method

The zirconium alizarin method is used to measure the concentration of fluoride ions in the solution both before and after the adsorption process. The testing process was carried out in accordance with IS3025(part60):2008.

The color of the produce gradually fades from red to yellow as the amount of fluoride increases, and as a result, it deviates from Beer's law. The color produced by a quantity of ordinary fluoride solution is compared to that produced by zirconium alizarin reagent.

Chemicals employed for the purpose of this study, the following substances are needed: concentrated sulphuric acid (H2SO4), concentrated hydrochloric acid (HCl), concentrated zirconyl-oxychloride (ZrOCl2.8H2O), and alizarin sodium mono-sulphate (alizarin red S).

The chemicals employed are all of the analytical reagent caliber.

F. Experimental Procedure

Preparation of Calibration Curve:

- Standard fluoride solutions are generated in 100 ml beakers in a series of dilutions with fluoride concentrations ranging from 0 to 1.0 mg/L.
- Each solution receives 5.0 mL of the zirconium alizarin reagent. For the exact one hour needed for color development, all solutions are left.After reacting with the reagent, the color of the solution changed from red to yellow as the concentration of fluoride increased.
- The spectrophotometer is turned on and given a 30-minute warm-up period. The instrument's wavelength has been set at 570 nm. As a reference, distilled water is used as the blank solution.
- The spectrophotometer is used to read the absorbance for each concentration of fluoride solution prepared in step 2 after an hour. AThe preparation of a calibration curve for concentration versus absorbance.
- Following the creation of the calibration curve, the same process can be used to test samples with unknown fluoride concentrations at 570 nm wavelength, and the associated absorbance values are reported. The relevant concentrations are calculated using the calibration curve.
- Up to a fluoride concentration of 0.05 mg/L, this approach can be used to estimate fluoride content.

G. Adsorption studies

Adsorption studies are carried out in various steps.

H. Determination of optimum dosage and optimum contact time

- Five sets of 250 ml glass beakers are taken with four beakers in each set. Each beaker contains a 100 ml sample with a fluoride concentration of 10 mg/L. Tulsi powder is added in increments of 0.1, 0.2, 0.3, 0.4, and 0.5 grams to each set of four beakers.
- The liquid in each beaker is constantly stirred. At the conclusion of each contact time of one hour, two hours, three hours, and four hours, a sample from each set is taken.superfluous to each beaker is collected and tested in the spectrophotometer to determine the absorbance value for each sample at 570 wavelength in nm.
- The concentration of fluoride remaining in each sample after the appropriate contact hours is calculated from the calibration curve.The dosage chosen as the optimal dosage corresponds to the sample with the least quantity of leftover fluoride, and the corresponding time is noted as the optimal concentration.

I. Determination of effect of initial concentration of fluorides onadsorption

J. Following the identification of the ideal dosage and contact time, the following is researched to determine how starting concentration affects the adsorption process

- 250 ml glass beakers are filled with 100 ml samples with initial fluoride concentrations of 5, 10, 15, and 20 mg/L.
- Tulsi powder is added to each of the beakers in the recommended dosage of 0.4 g.
- The beakers are continually swirled for three hours (the ideal contact period).
- To evaluate absorbance at 570 nm wavelength, the necessary amounts of supernatant from each beaker are obtained and analyzed in a spectrophotometer.
- Using the absorbance values from the calibration curve, the residual fluoride in each sample is calculated, and readings are recorded.

K. Determination of effect of pH on adsorption

It has been noted that the standard solution's initial pH value is 6.5.

Five samples with an initial fluoride content of 10 mg/L are collected, and their pH values are changed from 2.5 to 8.5 using either sodium hydroxide solution or sulfuric acid, depending on whether they are in the acidic or alkaline range.

Each beaker receives 0.4 g of tulsi powder and is given a 3-hour contact time.

After the requisite amount of supernatant from each beaker has been collected, the absorbance of each sample at 570 nm is measured using a spectrophotometer.

The residual fluoride concentrations are determined from the absorbance values using a calibration curve, and the readings are recorded.

L. Calculation Of % Removal Of Fluoride

% removal
= (Initial fluoride concentration-fluoride concentration after contact period)/ (Initial fluoride concentration)

V. RESULTS AND DISCUSSION

First, a calibration curve between fluoride concentration and absorbance is produced. As determined by the spectrophotometer, absorbance values for various known fluoride concentrations are reported in Table 1 and shown as a graph in Figure 1.

In order to find the ideal dosage and contact time, an experiment was conducted. The results are provided in Table 2 and as a graph in Fig. 2.

Table 3 and Fig. 3 both provide information on the impact of the initial fluoride concentration on the adsorbent's ability to remove fluoride.

The final findings of the investigation into the impact of pH on the removal effectiveness of adsorbent are shown in Table 4 and are The final findings from the investigation into how pH affects an adsorbent's capacity to remove contaminants are shown in Table 4 and graphed in Fig. 4.

Table 1: Concentration vs Absorbance for preparing Calibration

Sl. No.	Concentration, mg/L	Absorbance
1	0.2	0.009
2	0.5	0.01
3	0.8	0.011
4	1.0	0.012

curve

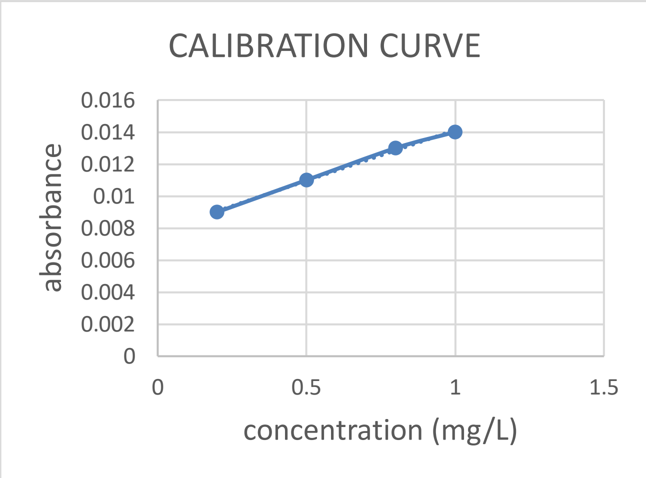

Figure 2: Calibration Curve- Concentration vs absorbance

Table 2: Variation of % Removal with variation of dosage of Tulsi powder

Dosage, g/L	% removal
0.1	82.5
0.2	88.0
0.3	89.3
0.4	90.6
0.5	86.6

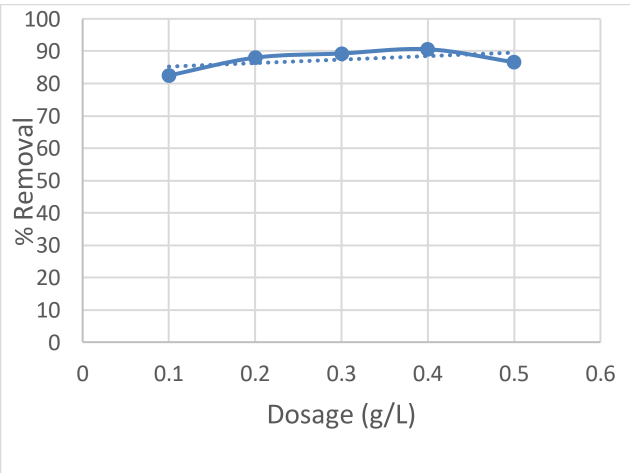

Figure 3: Dosage of Tulsi powder vs % removal of fluoride graph

Table 3: Variation of % removal with Initial Fluoride concentration

Initial concentration, mg/L	percentage removal
5	73.0
10	89.5
15	92.5
20	95.0

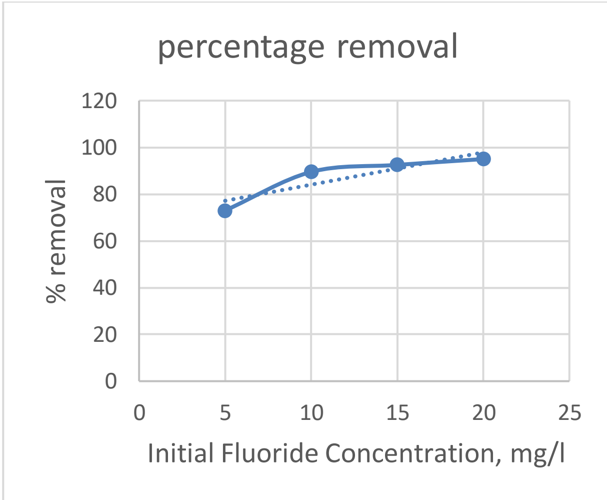

Figure 4: Initial fluoride concentration vs % removal graph

Table 4: Variation of % removal with change in pH value of sample

pH	% fluoride removal
2.5	96.0
4.0	93.0
6.5	89.5
7.0	87.0
8.5	76.0

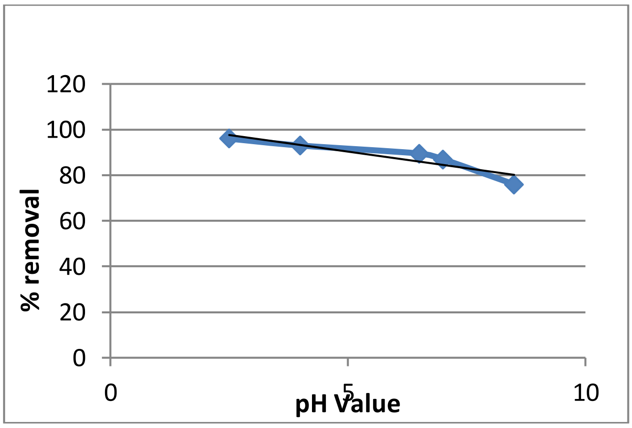

Figure 5: pH of the sample vs % removal of fluoride graph

VI. RESULTS AND DISCUSSION

- The calibration curve reveals a linear relationship between absorbance and concentration.
- For all dosages of the adsorbent (Tulsi powder), the

fluoride removal percentage rose with increasing contact time and reached a maximum value at a contact time of 3 hours. Three hours later, a modest decline in the removal percentage is seen. Maximum removal of 90% is discovered to be achieved at a dosage of 0.4 g/L.

- It has been found that the initial concentration of fluorides had an impact on how well tulsi powder was removed from water. Fluoride elimination percentage rose along with the original concentration. Even though the percentage reduction is limited at lower beginning fluoride concentrations, the water after treatment nevertheless conforms with the concentration. It can be concluded that the % removal is higher for higher initial concentration. But it is seen that even at low concentration, though % removal is less, Tulsi powder reduced residual fluoride concentration to permissible level.
- From the study, it can be concluded that the % removal of fluorides using Tulsi powder is highly influenced by pH value. Fluoride removal % is observed to be high in acidic
- pH range.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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[7] It has been noted that at an initial fluoride concentration of 5 mg/L, only 73% of the fluoride is removed. This results in a fluoride level that is 1.35 mg/L after treatment, which is significantly less than the 1.5 mg/L permitted limit defined by IS 10500 - 2012. The removal rate is 95% at a starting fluoride concentration of 20 mg/L, leaving a residual fluoride concentration of 1 mg/L.

[8] The amount of fluorides removed is significantly impacted by the pH variation of the sample. With a drop in pH, the percentage removed rose. Although the percentage reduction is modest at lower fluoride beginning concentration levels, the water after treatment nevertheless conforms well with the permitted fluoride limits set by IS 10500 - 2012.

[9] It follows from the study that as Tulsi powder dosage increased, so did the percentage of removal.

[10] Fluoride elimination increased with contact time, reaching its maximum during a 3-hour contact period.

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