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De-fluoridation of Water by using Laterite Stone

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***Abstract* – Occurrence of elevated concentration of fluoride in Ground water/surface water is a threat to the provision of potable water. The present study intends to use laterite for effective removal of fluoride from water. Samples heat treat at 400ºc performed better in fluoride adsorption. The mechanism for fluoride adsorption in the present study was attributed to process ion exchange between hydroxide ion of the laterite surface and fluoride ion in the solution.**

***Keywords* – Laterite soil, adsorbent, constructed soil filter (CSF), fluoride adsorption.**

I. INTRODUCTION

WATER is one of the most important elements for all forms of life and is indispensible to the maintenance of life on the earth. Safe drinking water is the primary need of every human being. Pure water is scarce and is not easily available at all. Water may be contaminated by natural sources or industrial effluents. One such contaminant is fluoride. Fluoride is a normal constituent of natural waters and its concentration varies depending on the water source. WHO standards and BIS, 105000, 1991 permit only 1.5 mg/l as the upper possible limit for fluoride in drinking water for Indian context. Fluoride is beneficial when present within permissible limits of 1.0-1.5 mg/l. Majority of fluoride intake for human beings are through WATER. The fluoride level in India ranges from 2-29 ppm (Tewari A et.al 2009. An excess fluoride in drinking water causes dental fluorosis, skeletal fluorosis. It not only affects teeth and skeletal but its accumulation over a long period of time can lead to change in DNA structure as well.
De-fluoridation of drinking water is one of the important remedial measures to solve high fluoride problem in drinking water. De-fluoridation is the process of removing excess naturally occurring fluoride from drinking water. Fluoride is commonly present in ground water than in surface water mainly due to leaching of minerals.

The present study reports the quality performance and treatment of drinking water containing fluoride in KALENAHALLI located at TUMKUR district. The data obtained from TUMKUR MUNICIPAL CORPORATION has revealed the higher fluoride content in Tumkur region. Higher concentration of fluoride 2mg/l is reported from Kalenahalli village of Tumkur district. The problem of fluoride contaminated ground water and its remediation has been a subject of discussion among many investigators across many countries in the world. And irreversible health damage, known as fluorosis.
Occurrence of excessive fluoride in ground water causes serious And irreversible health damage, known as fluorosis

This study investigates the removal of fluoride from drinking water by using laterite stone, which makes it an adsorbent applicable to fluoride removal. Laterite is useful adsorbent and low cost alternative for fluoride removal from drinking water.

The fluoride removal efficiencies were monitored. Various parameters such as flow rate of water, size of laterite grains were considered to monitor the performance of laterite.
At present twenty nine countries including India are facing problem due to excess fluoride in ground water.
A conservative estimate of fluoride victims around the globe, at present is 67million while 64million are at risk.

Different technologies are available for removing the excess level of fluoride so that the water quality may be brought to acceptable levels as per the recommendation of WHO
These include:

- Ion exchange
- Reverse osmosis
- Precipitation
- Adsorption
- Nano-filtration
- Electro-coagulation
- Membrane technique method

Above mentioned technologies are available for reducing/removing the excess level of fluoride, so that the water quality may be brought to acceptable levels as per the recommendation of WHO. The choice and utility of a particular technique is judged from its simplicity, efficiency and cost effectiveness.

Considering the above technologies adsorption has several advantages and it has chosen in this investigation.
The present study is intended to use laterite for effective removal of fluoride from water.The present study is intended to use laterite for effective removal of fluoride from water. Laterite is a weathered rock available abundantly in several parts of the country. It is therefore a readily available, low cost material; moreover the

operation process is simple and can be used by rural people also.
Laterite stone mainly contains iron oxide/hydroxide, clay minerals and quartz.

Desirable Characteristics of Defluoridation Process
Cost effective

- Easy to handle or operate by the people.
- Should not affect taste of water.
- Should not add other undesirable substances to treated water.
- Independent of input fluoride concentration, alkalinity, pH, temperature.

Objectives-

- The main objective of this study is to remove fluoride in drinking water.
- To study performance of laterite stone as a raw sample and preheated sample.
- To investigate the impact of fluoride on health.
- To study and understand the fundamentals of laterite soil based constructed soil filter (CSF) system.

Materials and Tests:
Material: Laterite soil, Sand, constructed soil filter system.

Tests: various tests were conducted to know physical & chemical properties of water sample.
Table-I: Tests results

SL.NO	NAME OF TEST	RESULT	PERMISSIBLE RANGE	INFERENCE
1	pH	5.3	6.5-8.5	Acidic
2	Acidity	44	-	-
3	Fluoride	2mg/L	1-1.5mg/L	Excess
4	Chloride	90mg/L	250-1000mg/L	Good for drinking
5	Residual chlorine	0	0-0.2mg/L	Good for drinking

Tests Procedure:
pH: pH of water sample is determined by using pH meter. Procedure as follows:

- Prepare a buffer solution of known pH of 4-7.
- Dip the electrode in known buffer solution and calibrate the pH meter. Now wash the electrode using distilled water.
- Now dip the electrode in the water sample & note down the direct ph value of water sample.

Result: pH of water sample is found to be 5.3.
Inference: permissible range 6.5-8.5, the obtained result is within the range, hence it indicates water is acidic
Acidity: acidity of water sample is determined by following procedures:

- Pipette out 25ml of water sample into conical flask.
- Add 2 drops of methyl orange indicator.
- Titrate it against 0.02 N hydroxide solution. The end point is noted when colour changes from orange red to yellow.
- Then 2 drops of phenolphthalein indicator is added & titration is continued till a pink colour just develops. The volume of the titrant used is noted down.

Result: methyl orange acidity =0 mg/l Phenolphthalein acidity=44mg/l
Inference: the water is acidic

Chloride test: chloride content in water is determined by following procedures:

- Take 25ml of water sample in the test bottle
- Add 5 drops of chloride reagent-1 & mix well until a distinct yellow colour develops.
- Add chloride reagent-2, shake well after each drop until the colour changes from yellow to red. Count the number of drops of cl-2 required for colour change.
- Chloride (as cl), mg/l = no. of drops x10 Result: chloride content in water sample = 90mg/l

Inference: permissible limit =250-1000mg/l, obtained value is less than permissible range hence water is good for drinking.

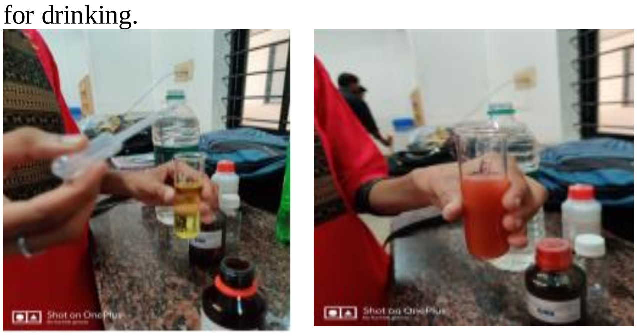

Fig.1. (a)Chloride test (b) Fluoride test

Fluoride test: fluoride content in water sample can be determined by following procedures:

- Take 5ml of water sample in the test tube.
- Shake well the fluoride reagent & then add 5 drops to the water sample. Mix the content.
- colour that forms is compared with the fluoride colour chart & record the fluoride value.
- Result: fluoride content in water sample is found to be=2mg/l

Inference: permissible limit=1-1.5mg/l, obtained result is more than permissible value; hence water is excess in fluoride content.

Fig.2. Residual chloride test.

Residual chloride: residual chloride content in water can be determined by following procedures:

- Take 5ml of water sample in test tube.
- Add 5 drops of residual chlorine reagent & mix well. The colour that form is compared with the residual chlorine colour chart & record the residual chlorine value.

Result: residual chloride content in water =0mg/l

Inference: permissible range is 0-0.2mg/l, the obtained value is less hence good for drinking.

Pre-Treatment of Laterite Stone

We had conducted tests on Laterite stone to know its composition we found that the laterite stone comprises major component of silica, aluminum, and iron oxides with minor component of different metal oxides viz. sodium, potassium, calcium, magnesium, manganese & titanium.

After testing the stone pre-treatment of laterite stone is done.

- The raw laterite is washed with water three times to eliminate any adhering dirt and soluble compound on its surface.
- This sample is placed in an oven at 105ºc for 48 hours to remove excess water and moisture.
- The dries laterite stone was ground and sieved into relatively homogeneous particle sizes ranging from 0.5 to 1 mm.
- This sieved particle is stored in tightly closed bags.

II. METHODOLOGY

The CSF system is constructed as per the plan.

- The laterite filter medium is placed, at the bottom of cylinder medium sized stone is placed, at the middle layer finely grounded laterite is placed, & at the top of cylinder fine sand is placed. Each layer should be 5cm thick.
- The distribution of water over the media is achieved via pumping, piping and distribution arrangements.
- The design has suitable provision for manual removal of collected fluoride sample from laterite media.
- The process can be run on batch as well as continuous mode. The water is piped & applied on the top surface of CSF as shown in fig.
- Water firstly percolates through the filter media, filter media get saturated after the complete saturation period the mechanism of solute –laterite interaction takes place.
- Mechanism includes laterite is primarily composed of Si, Al & iron oxides. When it is soaked in water for several hours the oxides get converted to Oxo hydroxides of Si, Al,& Fe. The Si-o & Al-o bonds are much stronger than Fe-o bonds. The governing interaction for metal ion-laterite is expected to be of ion exchange type. Once the ion exchange method completes the filtered water is obtained. The filtered water then gets collected in the collection tank.
- Again the desirable quality of water is checked.

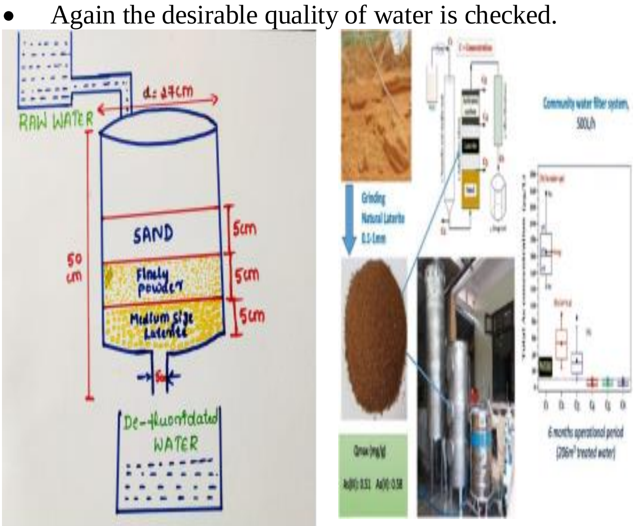

Fig.3. (a)Template. (b) Schematic representation of CSF

III. CONCLUSION

1. CSF with laterite soil medium facility shows high degree removal of COD,BOD, suspended solids, and turbidity thereby imparting clearness to water, color as well odor removal and total green ambience.
2. CSF is only one of its kinds which prove a better option to treat, recycle and reuse waste water for non-potable water as from gardens, washing roads, floors, cars, and for construction.
3. This process helps to reduce the fluoride from an initial concentration of 2mg/L to 1.2mg/L

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