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RESEARCH ARTICLE

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A PRELIMINARY ATTEMPT TO REDUCE TOTAL DISSOLVED SOLIDS IN GROUND WATER USING DIFFERENT PLANT PARTS

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ABSTRACT

The present study is a preliminary attempt to explore plant materials such as Indian gooseberry bark (*Phyllanthus emblica*), lemon peel (*Citrus limon*), peanut husk (*Arachis hypogaea*) and vetiver root (*Vetiveria zizanoides*) for reducing the total dissolved solids (TDS) in a domestic ground (hard) water. The water samples were collected from bore well in the out skirts of Chennai to screen the TDS ,which was around1400ppm (parts per million) using a TDS meter. The selected plant materials were packed in vertical glass columns separately and 50mL of hard water is supplied to the column to switch on the process with the flow rate of 10 ml per minute. The reduction of dissolved solids content in the samples were screened .The %decrease of TDS in the elute water samples are calculated for both first loading and second loading. It is evident that vetiver root has shown a maximum reduction in TDS (55.93%) followed by gooseberry bark (42.14%) , lemon peel (42%) and peanut husk (41.14%).

KEYWORDS

TDS, domestic ground (hard) water, Indian gooseberry bark, lemon peel, peanut husk, vetiver root, glass column.

INTRODUCTION

Ground water is one of the portable water resources available for both domestic and industrial purposes. Most important attributes of ground water are more availability and economic resource. In Tamil Nadu, hard rock formations occupy 73% of the total geographical area and the remaining area is occupied by sedimentary rocks. Ground water is extracted from these rocks by means of dug/tube/bore wells. Ground water pollution has been reported throughout the developing countries and it is a major threat to the environment. Instances of ground water pollution have been reported from Ambattur, Madhavaram and Manali in and around Chennai as well as Cuddalore and Pondicherry regions. The ground water in areas around Chennai such as Ambattur Industrial Estate, Chrompet and Manali has large content of toxic heavy metals many times exceeding the Bureau of Indian Standard (BIS) (Central Ground Water Board, March 2009). The toxic heavy metal concentration is also high in areas where the industrial activity is more. The domestic areas also reported to have high levels of ground water contamination.

In domestic areas around Chennai the ground water pollution is mainly due to high TDS content. TDS can be explained as the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. Some dissolved solids come from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms. Dissolved solids also come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a non-metal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge. Water may also pick up metals such as lead or copper as they travel through pipes used to distribute water to consumers. The EPA Secondary Regulations advise a maximum contamination level (MCL) of 500mg/liter (500 parts per million (ppm)) for TDS. Numerous water supplies exceed this level. When TDS levels exceed 1000mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium. These ions have little or no short-term effects, but toxic ions (lead arsenic, cadmium, nitrate and others) may also be dissolved in the water.

There are potential health effects caused due to high TDS content in drinking water. The hard water will taste bitter, salty, or metallic and may have unpleasant odours. High TDS water is less thirst quenching. High TDS interferes with the taste of foods and beverages, and makes them less desirable to consume. Some of the individual mineral salts

such as Nitrates, Sodium, Sulfates, Barium, Cadmium, Copper, and Fluoride that make up TDS pose a variety of health hazards such as causing stiffness in the joints, hardening of the arteries, kidney stones, gall stones and blockages of arteries, microscopic capillaries and other passages in which liquids flow through our entire body

Domestic water purifiers available in India use chemicals, activated carbon filtration, distillation, UV purification, reverse osmosis, ion exchange resin or a combination of technologies. Chemicals such as chlorine were used to bleach the water to remove biological contaminants in it. Bleaching of water is not preferred as it only kills the microbes in the water but it does not purify it as the water may contain toxic chemicals and other dissolved minerals. And chlorine treated water may affect liver and lead to hepatic damage. So this method using chemicals are now mostly not preferred in domestic water purification. Activated carbon (AC) filtration is a well-established technology for the reduction of a wide range of aesthetic contaminants, and is quite effective in the reduction of some health contaminants such as volatile organic compounds (benzene, trichloroethylene, and other "petroleum"-based contaminants). The main disadvantage of AC filters is that it serves as a breeding ground for micro-organisms. The organic chemicals that are adsorbed to the AC are a source of food for various types of bacteria. Distillation is the process of removal of impurities by boiling and condensing the water. Disadvantage of using distillation in domestic water purification is that it consumes more time and electricity. Reverse osmosis involves in removal of water impurities (both organic and inorganic source) by applying high pressure on the water to pass it through a membrane that can selectively remove the impurities from the water. Though RO purification is common in most domestic water filtration, it carries some disadvantages such as production of more waste water (reject water); RO filters are susceptible to high damage which is not easily detected, frequent change of RO membranes. UV water purification is by exposing Ultra-Violet light which kills most of micro-organisms but it is not effective lessening the TDS of the water. UV purifiers are successful for water systems with low TDS. Deionization (DI) is a water filtration process whereby total dissolved solids (TDS) are removed from water through ion exchange. DI resins attract non-water ions and replace them with water ions, leaving a more pure water form. DI has a relatively short filter cartridge life and once it begins to fail, the TDS level of the purified will rise exponentially.

New approaches are discovered to minimize or even eliminate the above mentioned defects and disadvantages of the water purification techniques. This approach uses herbal plants and their parts to lessen TDS content in the hard water. Most of the plants have the capacity to absorb inorganic mineral salts through roots and store them as organic minerals. Some plant parts have the capacity to adsorb the dissolved salts over their surface. Adsorption phenomena in some plants were already reported and been used as in the form of activated carbon filters. In this approach the herbal plant parts such as lemon peel, peanut husk, vetiver root and Indian gooseberry bark are used to infer whether they can reduce the hard water TDS content. The above mentioned cases of ground water pollution due to industrial activity in Chennai are solemnly due to high amount of dissolved salts and toxic heavy metal dissolution. Purification of the highly polluted ground water was so difficult and not economical. Using herbal approaches to reduce water pollution may be cost effective and simpler than other synthetic methods.

MATERIALS AND METHODS

SAMPLE COLLECTION

The hard water sample was collected from Kavarapalayam near Avadi, Chennai. The hard

water was collected through bore well from that region in a 5L capacity container and stored at room temperature.

TDS of the water can be determined based upon the electrical conductivity of water which is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids in water create the ability for that water to conduct an electrical current, which can be measured using a conventional conductivity meter or TDS meter. Initial TDS of the sample was noted as 1400ppm by using TDS meter. The important specifications of the TDS meter used in this approach are TDS Range: 0-9990 ppm (mg/L), ATC: Built-in sensor for Automatic Temperature Compensation of 1 to 50 degrees Celsius (33 to 122 degrees Fahrenheit), Accuracy: +/-3% and Factory calibrated to NaCl 342ppm; adjustable. Meter can be adjusted with a mini screwdriver.

SELECTION OF PLANT MATERIALS

The plant parts such as lemon (*Citrus limon*) peel, peanut (*Arachis hypogaea*) husk, vetiver (*Vetiveria zizanoides*) root and Indian gooseberry (*Phyllanthus emblica*) bark are used here to reduce the TDS of the hard water. It has been reported that lemon peel has capacity to adsorb Cobalt from aqueous solution (Amit Bhatnagar et al., October 2009). Carbon prepared from peanut husk can be used to clean wastewater by adsorbing Copper, Zinc, Lead, Nickel and Cadmium (S. Ricordel et al., March 2001 & Duygu Özsoy et al., November, 2007). Vetiver has been reported to adsorb many heavy metals and used in phytoremediation of contaminated water system (Yahua Chen et al., April 2004 & Wang Xiao et al., October 2009). The young branches of Indian gooseberry were used in folk medicine for water purification as it adds pleasant flavour to water Most of the plant materials are available throughout the year at low or no cost.

TREATMENT PROCESS

The plant parts were washed, dried and crushed into small pieces which could be loaded into separate glass column. Column has a capacity of 100mL and air dried before use. The 4 separate glass column were packed with crushed plant parts separately i.e., column 1 was packed with lemon peel, column 2 with peanut husk, column 3 with vetiver root and column 4 with Indian goose berry bark.

COLUMN PACKING

S. no	Column no.	Plant material used in packing column	Amount of plant material used
1.	Column 1	Lemon peel	6g
2.	Column 2	Peanut husk	6g
3.	Column 3	Indian gooseberry bark	6g
4.	Column 4	Vetiver root	6g

After packing the columns with respective plant materials, the column was washed with 50mL distilled water to wash out unwanted substances other than the plant parts. Then the

columns were allowed to dry and after drying the columns were loaded with 50mL hard water sample taken from the bore well and retained for about 10min. Then the water sample was allowed to flow slowly through the columns at a rate of 10mL/min. The TDS of the eluted water sample was measured using TDS meter and the readings were noted as in ppm (mg/L).

STEP 1 HARD WATER SAMPLE LOADING

S. no	Column no.	Vol. of hard water sample	Retention time	Flow rate
1.	Column 1	50mL	10min	10mL/min
2.	Column 2	50mL	10min	10mL/min
3.	Column 3	50mL	10min	10mL/min
4.	Column 4	50mL	10min	10mL/min

Then the columns were washed with 50mL distilled water thrice to remove the salts adsorbed over the plant materials. The columns were air-dried for 10min to remove moisture. Then the hard water sample was recycled back into the column to reduce further TDS at a flow rate of 10mL/min.The TDS of the recycled elute was measured and tabulated.

STEP 2 HARD WATER SAMPLE RELOADING

S. no	Column no.	Vol. of hard water sample (recycle)	Retention time	Flow rate
1.	Column 1	50mL	10min	10mL/min
2.	Column 2	50mL	10min	10mL/min
3.	Column 3	50mL	10min	10mL/min
4.	Column 4	50mL	10min	10mL/min

RESULTS AND DISCUSSIONS

The experimental results are tabulated in tables.1-3 and presented graphically in the figures .1 and .2. The discussions of the results obtained can be distinguished into the following.

HARD WATER SAMPLE INITIAL LOADING

Using the results tabulated in the table 1 the %decrease in TDS of the hard water in the first cycle (initial loading) can be ordered as vetiver root (37.86%) > Indian gooseberry bark (28.43%) > lemon peel (27.86%) > peanut husk (25%). The decrease percentage can be calculated as follows.

%decrease (in TDS) = 100 * (initial reading – final reading) / initial reading

Thus the vetiver root shows high TDS reduction in hard water sample and peanut husk shows less reduction in TDS.

Table 1
Percentage of Decrease in TDS

S. no	Plant material used	Initial TDS reading	Final TDS reading	% Decrease
1.	Lemon peel	1400ppm	1010ppm	27.86
2.	Peanut husk	1400ppm	1050ppm	25
3.	Indian gooseberry bark	1400ppm	1002ppm	28.43
4.	Vetiver root	1400ppm	870ppm	37.86

HARD WATER SAMPLE RELOADING (RECYCLE)

The recycled or reloaded hard water sample was measured before and after the loading into the column packed with herb parts. Using the results tabulated in the table.2 the %decrease in hard water TDS in the second loading or simply reloading can be ordered as vetiver root (29.08%) > peanut husk (21.52%) > lemon peel (19.60%) > Indian gooseberry bark (19.16%). Vetiver root shows high %decrease in TDS and Indian gooseberry bark shows less %decrease in TDS. There are variations in the first (initial loading) and second (reloading) loading of water sample which are listed below as

The peanut husk showed low reduction in TDS in both i.e. 1050ppm in first loading and 824ppm in second loading of samples, but the %decrease in TDS in first loading is 25% (least) and in second loading it is 21.52% (second high). This proves that peanut husk has capacity to be used more than once for TDS reduction than other plant parts.

The Indian gooseberry though reduces TDS in both loading (1002ppm) and reloading (810ppm) of hard water samples, also proved that it can be used only few recycles when compared to other plant parts as it has low %decrease in hard water samples reloading (19.16%) than sample first loading (28.43%).

All the plant materials showed decrease in TDS reduction between first and second sample loading.

Table 2
Hard water sample reloading

S. no	Plant material used	Initial TDS reading	Final TDS reading	% Decrease
1.	Lemon peel	1010ppm	812ppm	19.60
2.	Peanut husk	1050ppm	824ppm	21.52
3.	Indian gooseberry bark	1002ppm	810ppm	19.16
4.	Vetiver root	870ppm	617ppm	29.08

OVERALL TDS REDUCTION (HARD WATER SAMPLE LOADING AND RELOADING)

From table 3. the %decrease of TDS in hard water overall can be ordered as vetiver root (55.93%) > Indian gooseberry bark (42.14%) > lemon peel (42%) > peanut husk (41.14%). Vetiver root shows high TDS reduction than other plants and peanut husk showed the lowest %decrease of TDS. Thus vetiver root proves to be more effective reduction of TDS of hard water than any other plant materials used in this approach. And also peanut husk is capable of retaining its adsorptive property than other plant materials.

Table 3
OVERALL TDS REDUCTION

S. no	Plant material used	Initial TDS reading	Final TDS reading	% Decrease
1.	Lemon peel	1400ppm	812ppm	42
2.	Peanut husk	1400ppm	824ppm	41.14
3.	Indian gooseberry bark	1400ppm	810ppm	42.14
4.	Vetiver root	1400ppm	617ppm	55.93

FIGURE .1
TDS (ppm) REDUCTION

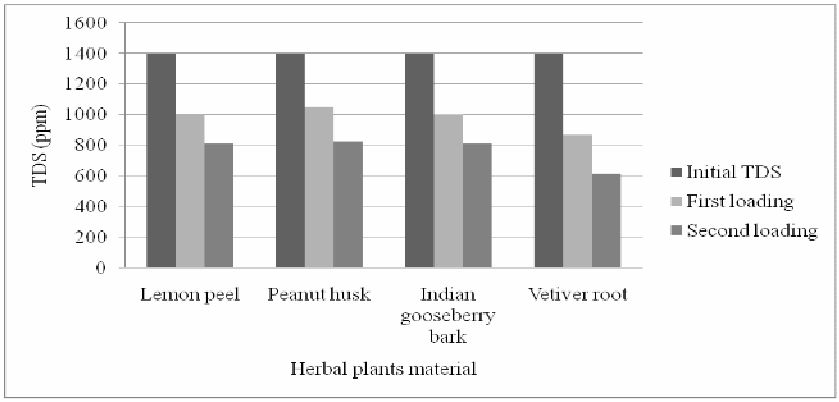

Figure .1

TDS reduction in ppm shown graphically in columns indicates the variation of TDS reduction between various plant herb materials

FIGURE .2 - %DECREASE IN TDS

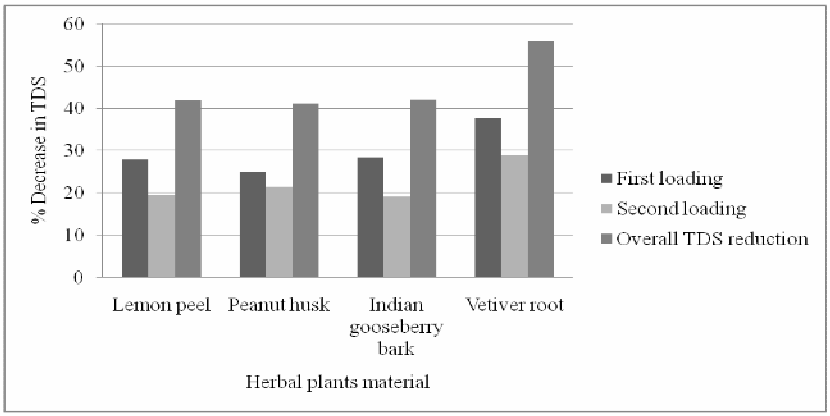

Figure 2 %Decrease of TDS shown graphically in columns indicates the variation of % decrease in between loading, reloading and overall loading of hard water samples.

4. SUMMARY

The reduction of TDS by using herbal plant parts proves to be effective and can be implemented in the field of water purification systems.The use of vetiver root in reducing the dissolved solids in the hard water thus made it portable for domestic use. The other plant materials such as Indian gooseberry bark, lemon peel and peanut husk was also found to reduce the dissolved solids effectively.The plant parts were crushed and packed in glass columns and then the hard water was fed to the column at equal flow rates to all the columns. Then the water eluted was found to have lower TDS than the initial hard water.The reloading of hard water for 2 to many cycles in the same columns i.e., column reusing can help in removing excess solids from the same hard water samples.Thus plants such as vetiver, Indian gooseberry, lemon and peanut have the potential in the treatment of hard water into soft water portable for domestic use.

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