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Efficiency of reactors composed of plant based absorbents in combination with sand and gravel for physicochemical parameters of different category water

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ABSTRACT

According to the world Summit of sustainable Development, the major reason for lack of safe water is either scarcity of water or contamination of water sources. Therefore this study eye on developing nations, seeks to find sustainable, yet economically and socially practical solution to the problems associated with polluted water. To fulfil the objectives of the present study, two medicinal value plants *Dhav (Anogeissuslatifolia wall.)* and *Aragvadha (Cassia fistula Linn.)* were selected and absorbents were prepared from the bark of both the plants. Then the reactors were prepared using the different compositions of sand, gravel, absorbents of *Dhav*and *Aragvadha* and cotton.Inthis way four filter reactors were prepared. The feeding rate of raw water is maintained at 0.5 litre per hour. The results revealed that *Dhav* plant absorbent was found more effective than*Aragvadha*. All reactors shows different efficiencies for different parameters suggesting that reactors should be prepared based on need or targeted parameters. Over all reactor 4 shows better efficiency for all the parameters. The main exclusivity of the present reactor is low cost with no electricity demand. The prepared reactors are environment friendly and easily implementable but further study is required toprove it on large scale.

Introduction

Water is one among the basic requirement for the survival of human race on this earth. Water is a key resource for human civilization, for human life, for our economy, agriculture and for every aspect of our existence. Water and its conservation have inevitably had a central place in the Indian ethosand in custom and culture (Ahamad *et al.,* 2022; Dinesha*et al.,* 2023). Water and water access are key not just to country's economic development but also for socio-economic equity and gender justice. Water is becoming a rare resource in the world (Tyagi *et al.,* 2020). In India alone the International water management Institute (IWMI) predicted that by 2025, one person in three will live in conditionof absolute water scarcity (IWMI, Bhutiani and Ahamad, 2018). Water as resource is under relentless pressure due to population growth, rapid urbanization, large scale industrialization and environmental concern (Ruhela *et al.,* 2022; Bojago *et al.,* 2023). The conservation of a better living environment requires fighting against all forms of environmental pollution. It is important that water is managed optimally and efficiently (Bhutiani *etal.,* 2016; Patel *et al.,* 2020; Bhutiani *et al.,* 2022).

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Wastewater is generated in almost all the human routine activities in all the sectors viz. industrial, domestic and agriculture. Most of the water supplied to a society returned as wastewater due to increased automation of life style (Singh *et al.,* 2021; Owodunni and Ismail, 2021). Therefore a huge quantity of wastewater is generated throughout the world both in developed and developing countries. In developed countries, almost all the quantity of wastewater generated is recycled or discharged after treatment due to availability of funds, skilled manpower and advanced technologies (Bhutiani *et al.,* 2017; Yin, 2010). At the same time, 70% of wastewater generated is discharged either in untreated or partially treated form in developing countries due to lack of funds, skilled manpower and advanced technologies (Bhutiani *et al.,* 2021). Wastewater discharged either in untreated or partially treated form causes the pollution of both surface water and groundwater. Drinking of this polluted surface and ground water causes different diseases in human beings (Khan *et al.,* 2013; Megersa *et al.,* 2014; Tiwari*et al.,* 2022). About 14000 deaths per day due to water pollution were reported by Anderson and Fenger (2003). The problem of ground and surface water pollution become more dangerous in developing countries such as India. Currently most of the India states are facing the problem of both quantity and quality degradation of both ground and surface water pollution. At the time India is facing the problem of wastewater generation and management. A lot of conventional and non- conventional wastewater treatment technologies are available but most of them have drawbacks like complex treatment process, requirement of skilled labour, high capital cost and high energy demand (Singh *et al.,* 2021). Biosorption is a low cost, easy to operate, no requirement of skilled labour, and environmental friendly technology of wastewater as compared to other (Singh *et al.,* 2021). A lot of literature is available using Biosorption technology for the treatment of natural as well as synthetic wastewater (Megersa *et al.,* 2014; Saleem and Bachmann, 2019; Chauhan *et al.,* 2019; Patel *et al.,* 2020; Shabaa *et al.,* 2021; Singh *et al.,* 2021; Owodunni and Ismail, 2021). But very few documents are available reporting the efficiency of plant based absorbents in combination with sand and gravel. Therefore in the present study an attempt has been made to assess the efficiency of two medicinal value plants (*Dhav* and *Aragvadha*) based absorbents in combination with sand and gravel for the treatment of tree different category water (Ganga water, Tap water and Sewage).

Material and Methods

Collection and preparations of bark ash:

The collection of selected plants part and ash preparation was performed as given below-

Step 1	*Dhava* and *Aragvadha* were collected from Chandi Devi hills Shyampur forest range and UAU, Rishikul Campus, Haridwar respectively
Step 2	They were dried in Sunlight for 7 days
Step 3	Dried bark weight of *Dhava* was 4.56 Kg and *Aragvadha* was 5.40 Kg respectively
Step 4	The calcinations of dried bark was done in Muffle furnace
Step 5	Bark was kept in *Sarav-samput* (Earthen pot with lid) and placed in furnace
Step 6	Desired temp. or set temp. of furnace was 550℃ for 120 minutes
Step 7	Weight of bark after Calcination was about 2.6 and 1.8 Kg respectively

Analysis of bark absorbent: Then the prepared absorbents were analyzed for appearance, odour, taste, touch, pH value, Loss on drying at 105°C,Total ash, Acid- insoluble ash, Water soluble extractive, Alcohol soluble extractive.

Material required for the preparations of Reactors:

Following materials were required for reactor preparation-

- Bark ash coarse grinded particle
- Sand
- Gravel
- Markin Cloth
- Cotton
- Bisleri Bottles (1 liter)
- Apparatus holding Stands
- Containers fitted with tap (5 lit. Capacity)

Method of the preparations of Reactors:

Step 1	Filtration apparatus was made by using empty Bisleri water bottles
Step 2	In brief, a tiny hole was made in the cap of the bottle and bottle was cut down from the bottom
Step 3	Bottle was inverted upside down
Step 4	To fabricate the filtration apparatus, cotton was placed near the neck of bottle
Step 5	Afterwards, Gravel, sand, markin cloth, charcoal or bark ash, markin cloth, sand layer was filled respectively, after the cotton layer

Method of the preparations of Reactors: After the material arrangements, next step is reactor preparations.The description of each reactor is presented in table 1.The schematic diagram of reactor prepared is presented in figure 1.

Water sampling and analysis

Tap water sample was collected from Gurukula Kangri Vishwavidyalaya, Haridwar. Ganga water sample was collected from Kashyap ghat, Haridwar. Sewage sample was collected from 27MLD sewage treatment plant (STP) located in Jagjeetpur, Haridwar. After collection all the samples were analyzed as per the standard methods prescribed in APHA (2011) and Trivedi and Goel (1986), Khanna and Bhutiani (2011). Then the experiment was run and after the experiment all the water samples were analyzed using the same methodology.

Table 1: Description of each reactor

Reactor	Description of layer				
	I layer	**II layer**	**III layer**	**IV layer**	**Cotton layer**
1	Sand (2 cm)	Gravel layer (2 cm)	Sand (5 cm)	Gravel layer (5 cm)	Diameter=1 cm Thickness= 1 cm
2	Sand (1 cm)	*Dhava* absorbent layer (8 cm)	Sand (3 cm)	Gravel layer (3 cm)	Diameter=1 cm Thickness= 1 cm
3	Sand (1 cm)	*Aragvadha* absorbent layer (8 cm)	Sand (3 cm)	Gravel layer (3 cm)	Diameter=1 cm Thickness= 1 cm
4	Sand (1 cm)	*Dhava* and *Aragvadha* absorbent layer (8 cm)	Sand (3 cm)	Gravel layer (3 cm)	Diameter=1 cm Thickness= 1 cm

Results and Discussion

The results of organoleptic and physicochemical parameters of both the plant bark ash is given table2.

1. **Organoleptic study:** Blackish coloured coarse bark chips. *Dhava* bark ash light black whereas *Aragvadha* is dark black in colour. Brittle and crisp in touch.

2. **Physicochemical parameters-**

- **pH Value:** The pH value of an aqueous liquid may be defined as the common logarithm of reciprocal of the hydrogen ion concentration expressed in grams per liter. The aqueous solution of the sample was used for pH measurement by pH meter. The pH of the *Dahva* plant ash was 8.27 and *Aragvadha* plant ash was 8.01.

- **Loss on drying:** The loss on drying test is designed to measure the amount of water and volatile matters in a sample when the sample is dried under specified condition. The loss on drying value of the *Dahva* plant ash was 2.90 and *Aragvadha* plant ash was 3.74.

- **Total ash:** The ash limit test is designed to measure the amount of the residual substance when sample is ignited under specified conditions. The total ash value of the *Dahva* plant ash was 23.11 and *Aragvadha* plant ash was 20.91.

- **Acid-insoluble ash:** The acid insoluble ash content was conducted to assess the % of

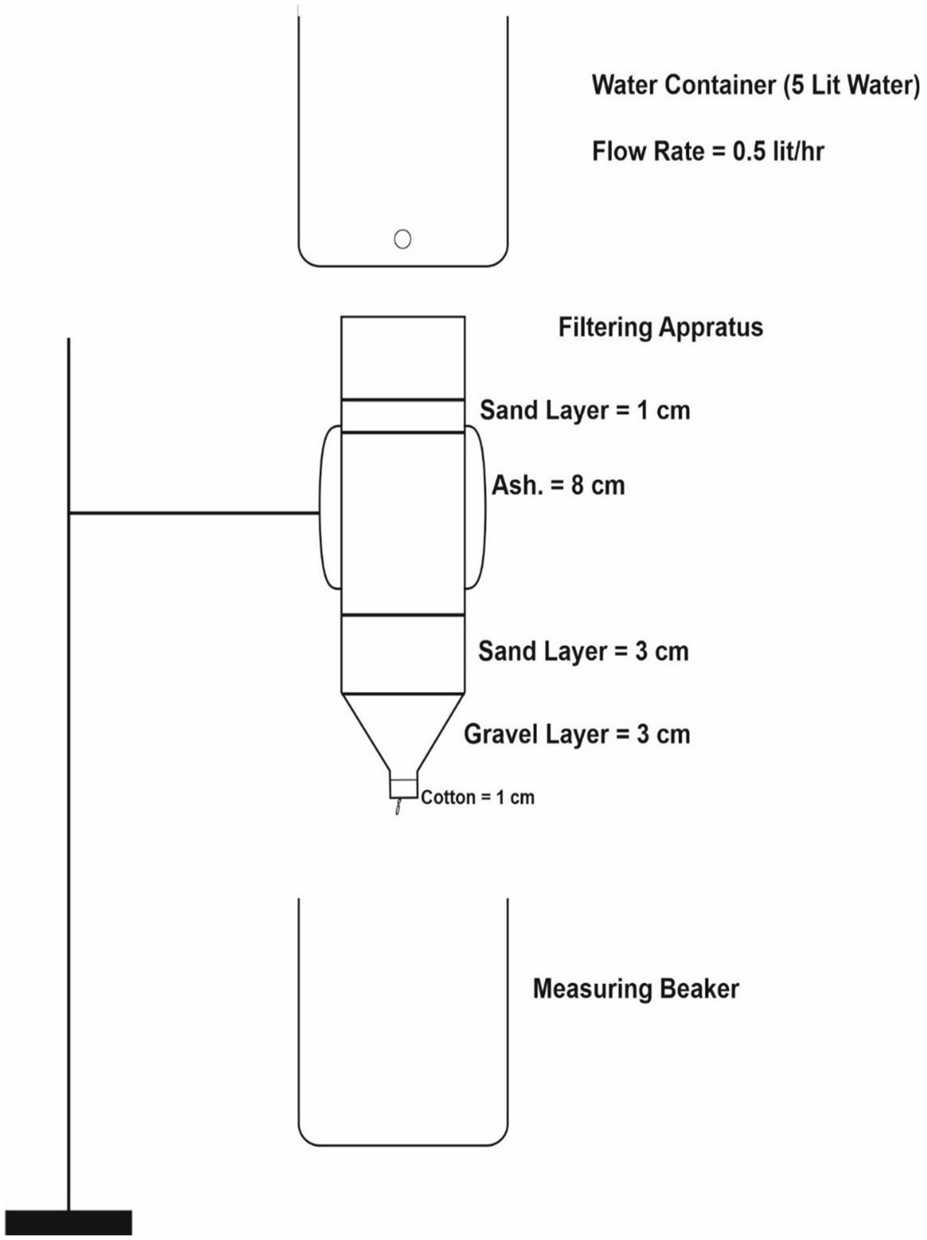


Figure 1: Schematic diagram of reactor

inorganic content of the sample, which is insoluble in dilute acid. The acid insoluble ash value of the *Dahva* plant ash was 1.05 and *Aragvadha* plant ash was 1.43.

- **Water soluble extractive:** This test was carried out to evaluate the water soluble extractive of the test drug. The water soluble extractive value of the *Dahva* plant ash was 2.15 and *Aragvadha* plant ash was 2.17.

- **Alcohol soluble extractive:** This test was carried out to evaluate the alcohol soluble extractive of the test drug. The alcohol soluble extractive value of the *Dahva* plant ash was 0.26 and *Aragvadha* plant ash was 0.34.

Table 2: Analytical description of *Dhava* and *Aragvadha*ash

SN	Test Parameters	*Dhava*	*Aragvadha*	Method reference
1.	Appearance	A light blackish coloured coarse bark chips.	A blackish coloured coarse bark chips.	Visual
2.	Odour	Odourless	Odourless	Smell
3.	Taste	Tasteless	Tasteless	Taste
4.	Touch	Brittle solid	Brittle solid	Touch
5.	pH	8.27	8.01	API
5.	Loss on drying	2.90	3.74	API Part II, Vol-1, Appendices-2.2.10
6.	Total ash	23.11	20.91	API Part II, Vol-1, Appendices-2.2.3
7.	Acid insoluble ash	1.05	1.43	API Part II, Vol-1, Appendices-2.2.4
8.	Water soluble extractive	2.15	2.17	API Part II, Vol-1, Appendices-2.2.8
9.	Alcohol soluble extractive	0.26	0.34	API Part II, Vol-1, Appendices-2.2.7

The results of all type of water i.e. Ganga water (GW), Tap water (TW) and Sewage (S) before and after the treatment with prepared reactors are given in table 3, 4 and 5. The percentage reduction is given table 6.

Turbidity

Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. Ideal value is below 1 NTU. It is important for health and aesthetic reasons. Minimum reduction of turbidity was observed in case of tap water (0%) by reactor 1 while maximum in case of sewage (67.6%) by reactor 4. The significant difference was found in mean turbidity among various treatments reactors {$F(TW)=10.99$, $F(GW)=5.37$, $F(SW)=38.44$, $p<0.001$). Turbidity decreased in each treated sample due to adsorption property of plant charcoal (ash) and slow sand intermittent filtration mechanism.

Total Solids (TS)

Total Solids (TS) is the amount of dissolved and suspended solids present in water. Minimum reduction of TS was observed in case of tap water (4.0%) by reactor 1 while maximum was also observed in case of tap water (39.5%) by reactor 4. The significant difference was found in mean TSamong various treatments reactors {$F(TW) =23.35$, $F(GW)=27.41$, $F(SW)=10.71$, $p<0.001$).

Total Suspended Solids (TSS)

Total Suspended Solids (TSS) is the amount of suspended solids present in water. Minimum reduction of TSS was observed in case of sewage (1.7%) by reactor 1 while maximum in case of Ganga water (79.0%) by reactor 2 and 4. The significant difference was found in mean TSS among various treatments {$F(TW)=33.35$, $F(GW)=180.58$, $F(SW)=1.25$, $p<0.001$).

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is the measure of salt dissolved in a water sample after removal of suspended solids. TDS is the residue remaining after evaporation of the water. Many dissolved substance are undesirable in water. Dissolved minerals, gases and organic substances may produce colour, taste and odour which are aesthetically displeasing. Some chemicals may betoxic and carcinogenic. Minimum reduction of TDS was observed in case of tap water (2.5%) by reactor1 while maximum in case of sewage (34.6%) by reactor 4. The significant difference was found in mean TDS among various treatments {$F(TW)=5.58$, $F(GW)=7.58$, $F(SW)=44.76$, $p<0.001$). These parametric values decreased in each treated filter due to adsorption of organic and inorganic matter.

Electrical Conductivity (EC)

The Electrical Conductivity (EC)measures the capacity of water to transmit electric current. The concentration of total dissolved solid is related to electrical conductivity. The conductivity increases as the concentration of TDS increases.The corrosiveness of the water increases as TDS and EC increases. Minimum reduction of EC was observed in case of tap water (2.5%) by reactor 1 while maximum in case of sewage (34.6%) by reactor 4. The significant difference was found in mean EC among various treatments {F(TW)=5.58, F(GW)=7.58, F(SW)=44.80, $p<0.001$). EC also decreased because of decreased amount of dissolved organic compound or salt due to adsorption.

pH

Measurement of pH is one of the most important and frequently used tests, as every phase of waterand waste water treatment and waste quality management is pH dependent. The intensity of the acidic and basic character of a solution is indicated by pH or hydrogen ion concentration. pH valuesfrom 0 to 7 are diminishing acidic, 7 to 14 increasingly alkaline and 7 is neutral. Minimum gain of pH was observed in case of Ganga water (6.0%) by reactor 3 while maximum in case of sewage (34.9%) by reactor 2. Reduction was observed only in tap water (5.8%) by reactor 1. The significant difference was found in mean pH among various treatments {F(TW)=19.24, F(GW)=34.77, F(SW)=34.77, $p<0.001$).

Biochemical Oxygen Demand (BOD)

The amount of oxygen required by microorganisms to decompose organic matter present in water and waste water is known as biochemical oxygen demand (BOD). The BOD of raw water indicates the extent of organic matter present, thus indicating the extent of treatment required for purifying this water to make it safe and wholesome.Minimum reduction of BOD was observed in case of Ganga water (5.9%) by reactor 1 while maximum in caseof Ganga water (47.7%) by reactor 2. The significant difference was found in mean BOD among various treatments {F(TW)=15.12, F(GW)=33.81, F(SW)=13.93, $p<0.001$).

Table 3: Physicochemical characteristics of Ganga water before treatment and after treatment with reactor 1, 2, 3, and 4

Parameters	Untreated Water	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Turbidity	2.0	1.6±0.2	1.4±0.2	1.5±0.3	1.3±0.3
TS	545.0	470.0±1.7	389.0±32.4	433.7±15.0	389.0±32.4
TSS	225.0	73.3±12.7	47.3±12.7	67.0±8.7	47.3±12.7
TDS	403.0	371.3±11.0	341.7±21.0	366.7±6.4	341.7±21.0
EC	620.0	571.2±16.9	525.6±32.4	564.1±9.8	525.6±32.4
pH	7.8	6.5±0.2	8.4±0.2	8.3±0.2	8.4±0.2
BOD	2.6	2.4±0.2	1.4±0.4	1.4±0.3	1.3±0.3
COD	76.0	74.2±1.9	62.7±7.6	62.7±8.3	62.4±8.3
Hardness	120.0	110.7±6.1	85.3±14.0	100.7±11.0	76.0±14.4
Calcium	40.1	40.1±0.0	26.0±3.5	30.7±4.6	24.0±0.0
Magnesium	19.5	17.2±1.5	14.5±2.7	17.1±1.8	12.7±3.5
Acidity	125.0	178.3±2.9	86.7±15.3	103.3±5.8	78.3±20.2

Table 4: Physicochemical characteristics of Tap-water before treatment and after treatment with reactor 1, 2, 3, and 4

Parameters	Untreated Water	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Turbidity	0.2	0.2±0.0	0.1±0.0	0.1±0.0	0.1±0.0
TS	372.0	357.2±5.2	307.0±39.2	320.4±32.0	225.1±48.6
TSS	19.0	12.9±1.9	9.4±1.6	10.1±1.7	9.1±1.5
TDS	353.0	344.3±3.8	297.6±37.6	310.3±30.5	294.0±38.3
EC	543.1	529.7±5.9	457.8±57.9	477.4±46.9	452.3±58.9
pH	7.4	6.9±0.2	8.2±0.4	7.9±0.3	8.6±0.2
BOD	3.8	2.9±0.2	2.4±0.4	2.9±0.3	2.3±0.5
COD	68.0	62.7±1.2	40.7±18.6	54.7±8.3	44.0±15.1
Hardness	286.0	248.0±8.0	197.3±26.6	239.3±9.0	190.7±32.3
Calcium	242.0	229.7±6.1	186.1±23.2	223.7±5.1	184.0±31.4
Magnesium	10.7	4.5±0.6	2.7±1.0	3.8±1.0	1.6±0.2
Acidity	155.0	198.3±7.6	126.7±15.3	126.7±5.8	120.0±20.0

Table 5: Physicochemical characteristics of Sewage water before treatment and after treatment with reactor 1, 2, 3, and 4

Parameters	Untreated Water	Reactor 1	Reactor 2	Reactor 3	Reactor 4
Turbidity	29.0	17.0±4.6	9.9±1.8	12.9±4.5	9.4±2.3
TS	877.0	746.3±6.7	732.3±4.5	734.7±4.0	720.7±7.5
TSS	519.0	510.0±5.3	496.7±9.5	490.0±6.0	489.3±17.5
TDS	358.0	244.3±14.0	235.7±5.0	244.7±2.1	234.0±14.1
EC	550.8	375.9±21.6	362.6±7.7	376.4±3.2	360.0±21.7
pH	6.2	6.8±0.2	8.4±0.2	8.3±0.3	8.3±0.1
BOD	129.0	114.7±4.6	100.7±8.3	105.3±9.9	96.7±4.6
COD	1280.0	832.0±128.0	306.7±16.7	538.7±218.4	304.0±154.3
Hardness	320.0	265.3±12.9	215.3±5.0	246.0±35.0	178.7±20.1
Calcium	120.2	76.1±5.6	34.7±6.1	48.1±17.5	31.7±8.5
Magnesium	48.7	47.1±1.5	43.7±0.3	48.3±4.8	36.1±3.5
Acidity	200.0	286.7±5.8	116.7±7.6	116.7±7.6	58.3±14.4

Table 6: Percentage reduction in different physicochemical parameters of Ganga water, Tap-water and sewage after treatment with reactor 1, 2, 3, and 4

Parameters	Reactor 1			Reactor 2			Reactor 3			Reactor 4		
	GW	TW	S	GW	TW	S	GW	TW	S	GW	TW	S
Turbidity	18.7	0.0	41.4	30.0	50.0	66.0	26.7	50.0	55.6	33.3	50.0	67.6
TS	13.8	4.0	14.9	28.6	17.5	16.5	20.4	13.9	16.2	28.6	39.5	17.8
TSS	67.4	32.3	1.7	79.0	50.5	4.3	70.2	47.0	5.6	79.0	52.1	5.7
TDS	7.9	2.5	31.8	15.2	15.7	34.2	9.0	12.1	31.7	15.2	16.7	34.6
EC	7.9	2.5	31.8	15.2	15.7	34.2	9.0	12.1	31.7	15.2	16.7	34.6
pH	16.2	5.8	-9.1	-7.7	-11.0	-34.9	-6.0	-7.8	-33.9	-7.7	-16.8	-34.2
BOD	5.9	22.8	11.1	47.7	36.8	22.0	45.5	24.6	18.3	48.5	40.4	25.1
COD	2.4	7.8	35.0	17.5	40.2	76.0	17.5	19.6	57.9	18.0	35.3	76.3
Hardness	7.8	13.3	17.1	28.9	31.0	32.7	16.1	16.3	23.1	36.7	33.3	44.2
Calcium	0.0	5.1	36.7	35.0	23.1	71.1	23.4	7.6	60.0	40.0	24.0	73.6
Magnesium	11.7	58.5	3.3	25.8	74.5	10.3	12.5	64.4	0.9	35.0	84.8	25.9
Acidity	-42.7	-28.0	-43.3	30.7	18.3	41.7	17.3	18.3	41.7	37.3	22.6	70.8

***GW=Ganga Water, TW= Tap Water, S= Sewage *Negative value = Increase in the value after the treatment**

Chemical Oxygen Demand (BOD)

The amount of oxygen needed to oxidize all the organic matter in waste water sample, a measure of level of organic pollution. Ideal Cod of water is 0. Minimum reduction of COD was observed in case of Ganga water (2.4%) by reactor 1 while maximum in case of Sewage (76.3%) by reactor 4. The significant difference was found in mean COD among various treatments {$F(TW)=7.50$, $F(GW)=6.96$, $F(SW)=49.05$, $p<0.001$). Due to *Vishaghna* and anti-microbial property of bothplants, BOD and COD of treated water might be decreased.

Total Hardness (TH)

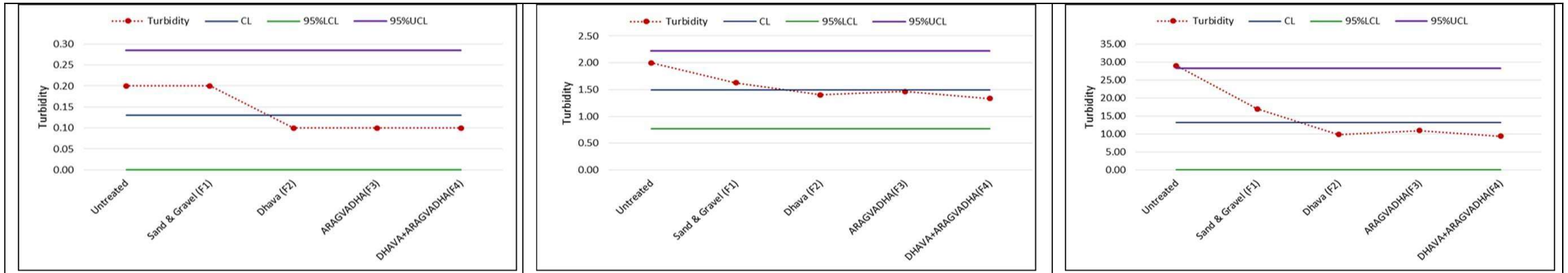
Water hardness is a traditional measure of the capacity of water to precipitate soap. Total hardness of water is defined as the sum of calcium and magnesium concentration. Hardness is temporary if it is associated with carbonates and bicarbonates and permanent if associated with sulphate and chlorides. Minimum reduction of TH was observed in case of Ganga water (7.8%) by reactor 1 while maximum in case of Sewage (44.2%) by reactor 4. The significant difference was found in mean TH among various treatments {$F(TW)=20.85$, $F(GW)=17.97$, $F(SW)=40.36$, $p<0.001$). Decreased in hardness of all treated water might be due to dissociation of Carbonate and Bicarbonate from calcium and magnesium compound as well as their adsorption.

Calcium and Magnesium

Minimum reduction of calcium was observed in case of Ganga water (0.0%) by reactor 1 while maximum in case of Sewage (73.6%) by reactor 4. The significant difference was found in mean calcium among various treatments {$F(TW)=13.58$, $F(GW)=52.15$, $F(SW)=68.27$, $p<0.001$). Minimum reduction of magnesium was observed in case of Sewage (3.3%) by reactor 1 while maximum in case of tap water (74.5%) by reactor 2. The significant difference was found in mean magnesium among various treatments {$F(TW)=121.81$, $F(GW)=8.99$, $F(SW)=20.56$, $p<0.001$).

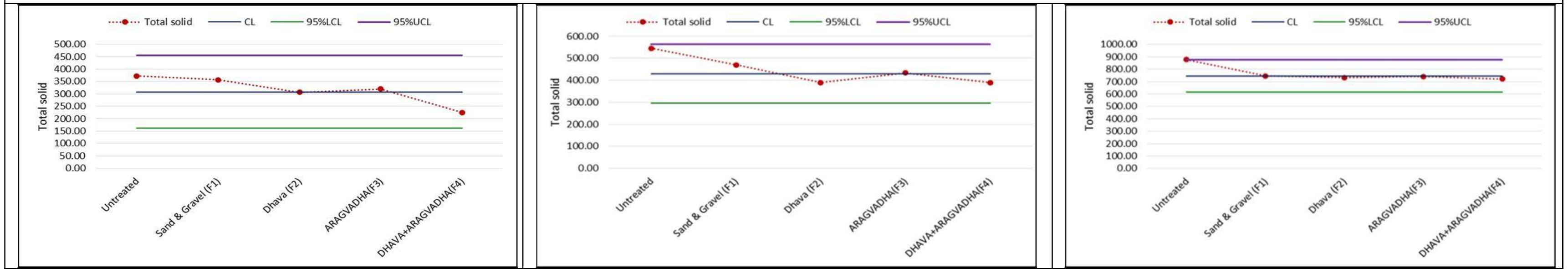
Acidity

Increased acidity of water causes Cancer, Cardiac and kidney diseases. Normal range= 150 mg/l. It is the sum of all titrable acid present in water sample. Minimum reduction of acidity was observed in case of Ganga water (17.3%) by reactor 3 while



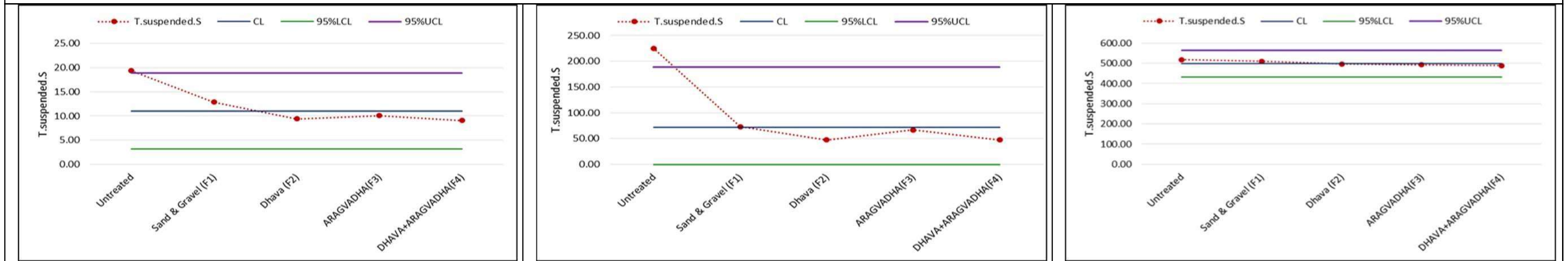
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 2: Effect on Turbidity in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



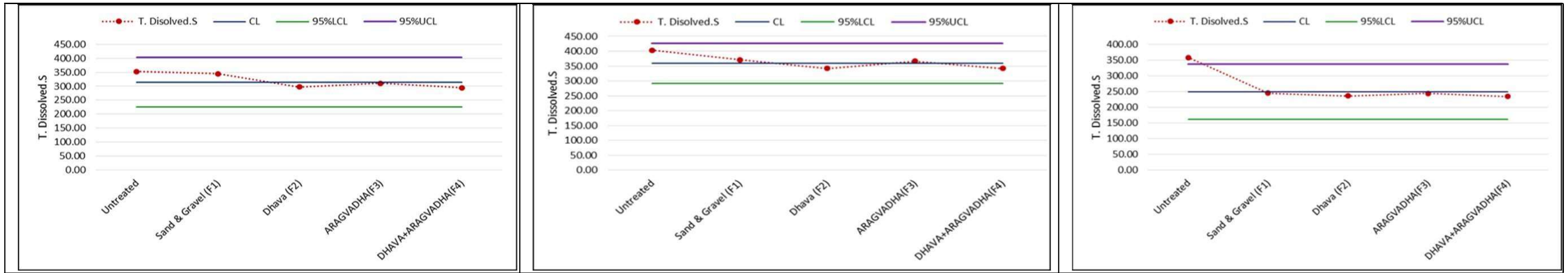
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 3: Effect on TS in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



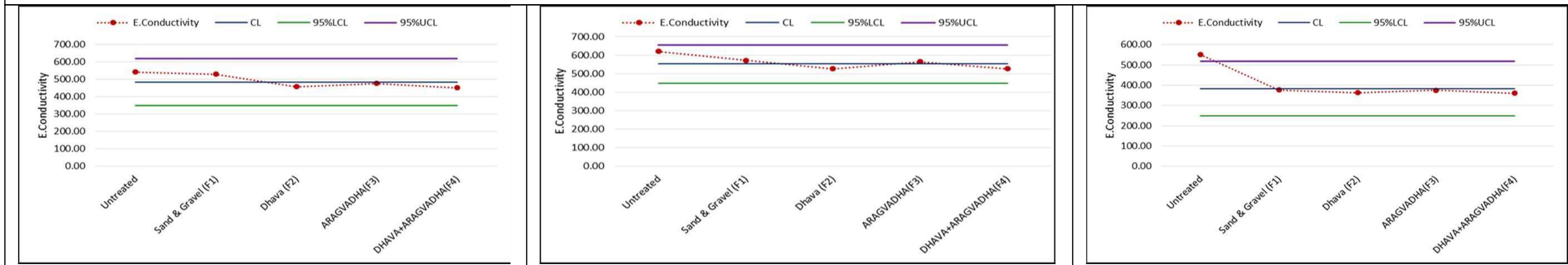
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 4: Effect on TS in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



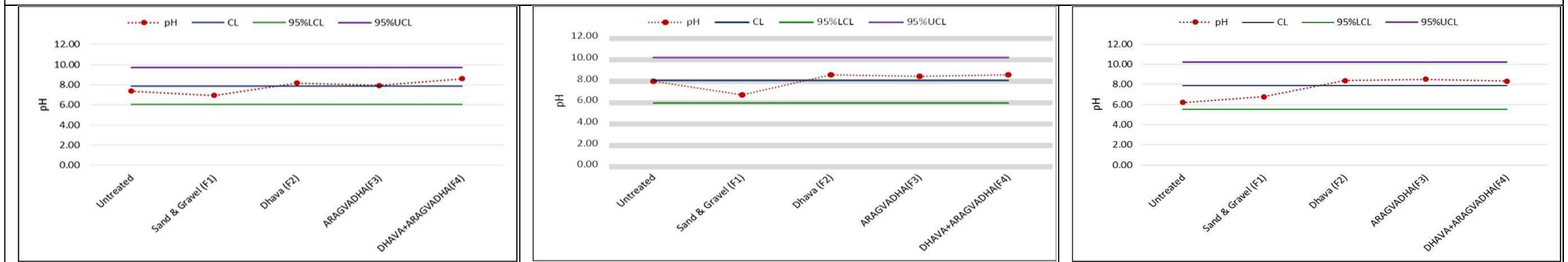
(a) Tap water (b) Ganga water (c) Sewage water

Figure 5: Effect on TDS in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



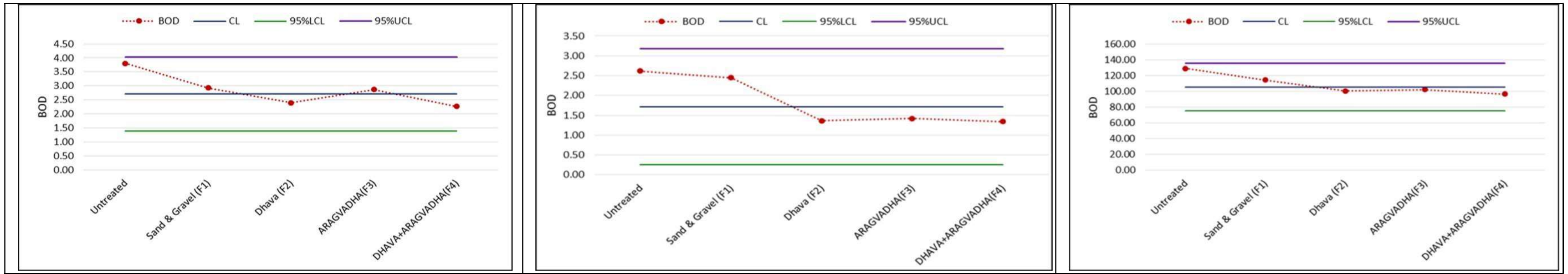
(a) Tap water (b) Ganga water (c) Sewage water

Figure 6: Effect on EC in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



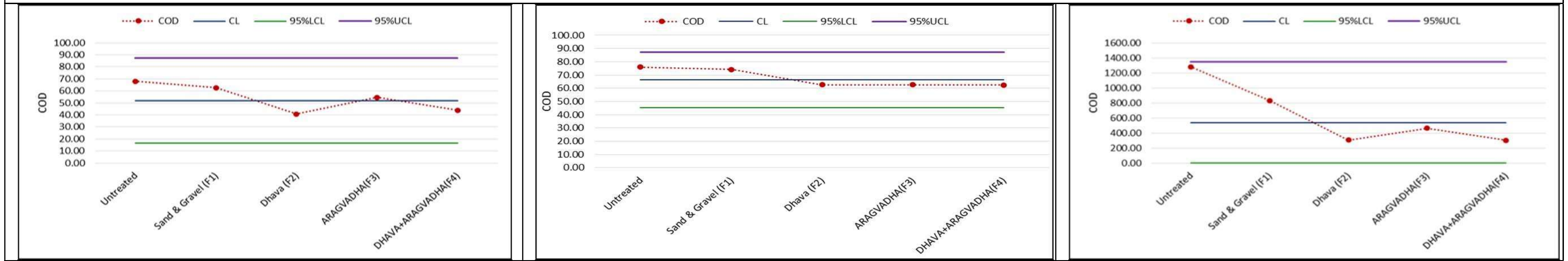
(a) Tap water (b) Ganga water (c) Sewage water

Figure 7: Effect on pH in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



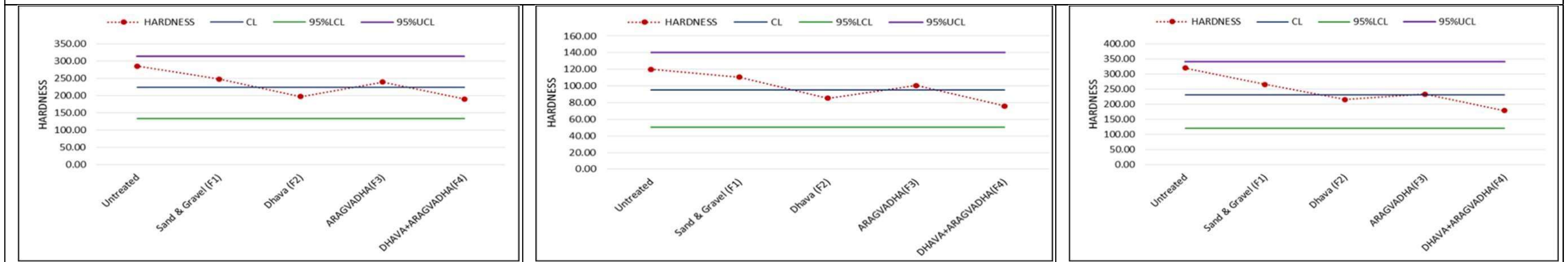
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 8: Effect on BOD in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



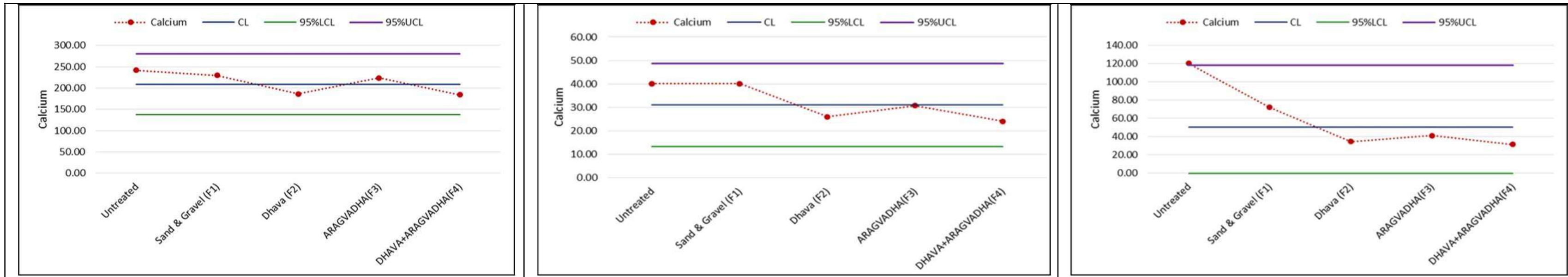
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 9: Effect on COD in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



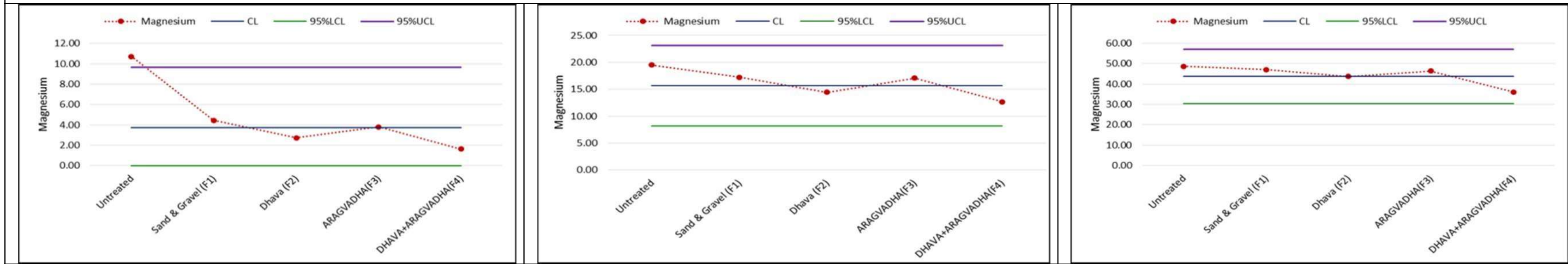
(a) Tap water	(b) Ganga water	(c) Sewage water

Figure 10: Effect on TH in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



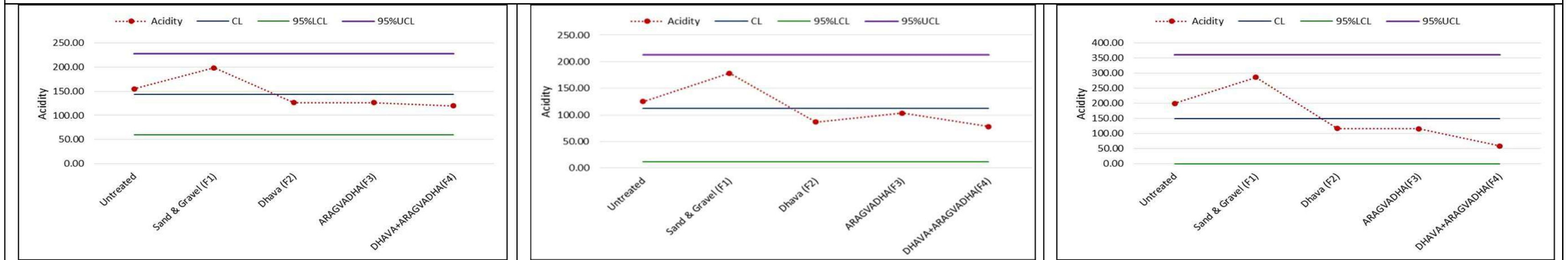
(a) Tap water (b) Ganga water (c) Sewage water

Figure 11: Effect on calcium in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



(a) Tap water (b) Ganga water (c) Sewage water

Figure 12: Effect on magnesium in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4



(a) Tap water (b) Ganga water (c) Sewage water

Figure 13: Effect on TH in (a) Tap water (b) Ganga water (c) Sewage water after treatment with Filter reactor F1, F2, F3, and F4

maximum in case of Sewage (70.8%) by reactor 4. Gain in reactor 1 was found in case of all types of water. The significant difference was found in mean acidity among various treatments {F(TW)=55.94, F(GW)=95.78, F(SW)=554.79, p<0.001). Increased acidity in reactor 1 might be due to silica while decreased in acidity value in reactor 2, 3, 4 may be due to neutralization process.

Conclusion

Dhava and *Aragvadha* are abundantly and easily available plants having medicinal properties. In our study we focused to establish their water purifying potential. Acharya sushruta described 9 plants and many other processes for purification of *Dushitjala, Dhava* and *Aragvadha* are two of them. In thisstudy we selected stem bark of both the plant as these parts are used for medicinal purpose. An 8 cm thick layer of ash of both the plants were used separately and in combination to prove their efficacy on total 20 different modern monitoring parameters of water. Efficiency of the reactors increased as the value of parameters in raw water increased. The effect of *Dhava* stem bark are better than *Aragvadha*stem bark ash while the combined effect of both the plants are much better than individual plants on almost all parameters. This study also proves the statement of *Acharya Sushruta* about *jalashodhana* properties of *Dhava* and *Aragvadha.* Many techniques such as chlorination, distillation, boiling, sedimentation and use of high tech filter have been utilized to purify water. These methods however, face major barriers such as high price, maintenance and conservationof fossil fuels. Our proposed solution to this problem involves production of low cost and effective water filter, which requires no electricity; it is environment friendly and easily implementable but further study is required to prove it on large scale.

Conflict of interest

The authors declare that they have no conflict of interest.

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