Biobased Treatment of Ground Water

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Abstract

Water is indispensable and one of the precious natural resources of our planet and it is getting polluted. So there is a great need for treating water that too a cheap and safe method. Hence an attempt was made in this study to treat water with bioproduct. About 10 different drinking water samples of Bharathidasan University (BDU), Trichirappalli were collected, analyzed and treated with natural product. The physico chemical and biological parameters such as colour, odour, taste, pH, acidity, alkalinity, total hardness, calcium, magnesium, chloride, nitrate, PO_4, SO_4, bacteria, and fungi were examined before and after treatment with *Phyllanthus embilca*. The values were compared with Bureau of Indian Standard (BIS) values. The results revealed that the alkalinity and total hardness of the water samples tested were more than the standard values before treatment. Treatment of the samples with *Phyllanthus embilca* removed the hardness.

KEYWORD: Bureau of Indian Standard, *Phyllanthus embilca*, total hardness, water treatment, physico chemical nature.

Introduction:

In developing countries more than 60% of the population has no access to drink pure drinking water (Khan et. al., 2000). Quality and quantity of water at a place plays a vital role in Health, Wealth and Prosperity of the region. Civilization, rapid industrialization and increased population have led to fast degradation of our environment. The provision of potable water to the rural and urban population is necessary to prevent health hazards (Nikoladze and Akastal, 1989). Water is one of the indispensable natural resources on earth and is it essential requirement of almost all living organism on earth for their existence. Ground water is the major source of drinking water in both urban and rural areas and it is the important source for the industrial and agricultural sectors. Ground water is considered as a dependable source of uncontaminated water because it occurs beneath the water table in soils and the geological formations. Ground water is an important source of water supply throughout the world. The sources of ground water are tube wells, hand pumps and bore wells (Sharma, 2004). It's used in irrigation, industries and domestic uses. The need for pure water continues to increase where perennial surface water sources are absent (Mariappan et. al., 2005). Groundwater meets domestic needs of more than 80 % rural and 50 % urban population, besides fulfilling irrigation needs of around 50% irrigated agriculture. Around two-fifth of India's agriculture output is contributed from area irrigated by groundwater (Aashvin et. al., 2013).

The quality of groundwater is controlled by several factors, including climate, soil characteristics, manner of circulation of groundwater through the rock types, topography of the area, saline water intrusion in coastal areas, human activities on the ground, etc. (Ramamoorthy and Rammohan, 2014). The ever growing demands for water resources coupled with the rate at which much of the earth's fresh water being adversely affected by human activities, demonstrate a developing crisis and horrible future if environmental water resources are not appropriately managed (Peterson, 1997). Though the purity of water decreases by human activities, increasing industrialization, urbanization and growth of mechanization are also the main factors for water crises.

The major rivering system is getting polluted continuously (Patil et. al., 2003). The effluents of industries with partly treated or untreated allow mixing with the near streams and rivers causing serious water pollution and people of the surrounding are affected by different water-borne diseases. Worldwide about 2.3 billion people suffer from water born diseases (Kowsalya et. al., 2007). Ground water contains microorganisms but groundwater has fewer microorganisms than surface water because of its long travel time in the subsurface environment (Abdul Jameel and Sirajudeen, 2005). More than five million people die from water related diseases every year and about 50% population of the developing countries are exposed to polluted water resources. Bacterial population is often considered as an important indicator of pollution (Nanthakumar, 2007). In India, 80% of the infectious diseases are water-borne. Typhoid, cholera, dysentery and infectious hepatitis are due to contaminated water (WHO, 2001).

Hence there is always a search for novel water purification methods for water. Traditionally water is purified either by adding few herbals like *Osimum sanctum* leaf or seed coats of *Elettaria cardamom* or storing water in copper vessel (Khurana and Sen, 2012). *Vetiveria zizanoides* was reported for its ability to improve the water quality in terms of clearness and pleasant smell (Vigneswaran et al., 2008). Herbals like *Strychnos potatorum*, *Moringa oleifera* and *Zee mays* had been reported for their ability to reduce alum in drinking water through its coagulation property (Raghuwanshi et al., 2007). Literatures of Indian Traditional Siddha Medicine also mention various methods to purify drinking water. One of the claims is that the water treated with the wood of *Phyllanthus emblica* become soft, safe for drinking and healthy living (Durairasan, 1999). Due to the high cost and solid waste produced by chemical and membrane filtration treatment technology for potable water an alternative method is the need of the hour. Such method must be ecofriendly and low cost. Therefore, this study is aimed to find out the role of plant based water treatment. The natural product *Phyllanthus emblica* wood was used to treat potable water of BDU Campus An attempt was made in this study to access the activity of *Phyllanthus emblica* on the removal of physiochemical and biological impurities present.

Materials and Methods

Ten different water samples were collected from Bharathidasan University, Tiruchirappalli, Tamil Nadu from ten different sites (Table 1). The water samples were collected either from sump or bore well of the selected site in polythene bottles and were kept in room temperature till use. The samples were collected in March 2010. The water samples were immediately brought to the laboratory to assess various physicochemical and biological parameters. Water temperature and pH were recorded at the time of sample collection, by using thermometer and pocket digital pH meter respectively. While

other parameters such as hardness, chlorides, alkalinity, nitrate were estimated in the laboratory by standard methods as prescribed by APHA, (1998). Biological analysis was done for all the samples before and after treatment. Biological characteristics of the collected water samples were analysed as per standard methods.

Table 1 Details of water samples studied

S. No.	Sample source	Code	Sampling site
1	Bore well	AB BW	Administrative block
2	Sump	AB S	Administrative block
3	Bore well	GD BW	Geology Department
4	Sump	GD S	Geology Department
5.	Bore well	H BW	Hostel (Girls)
6	Sump	H S	Hostel (Girls)
7	Bore well	Q BW	Quarters
8	Sump	Q S	Quarters
9	Bore well	BD BW	Botany department
10	Bore well	CDE BW	Center for distances education

Preparation of plant material

Good quality dried *Phyllanthus emblica (*Nellikattai) wood was collected from local traditional medicine shop (Nattu Marunthu Kadai), Tiruchirappalli. Wood was cleaned and dried under shade. The coat from the wood was removed. Fine powder was prepared by using mortar and pestle and this powder was stored in air tight container and this was used for further study.

Treatment with *Phyllanthus emblica*

Water samples for study purpose were collected from bore well and sump water from ten different sites of Bharathidasan University (BDU), Tiruchirappalli. Treatment was given directly to the water by using *Phyllanthus emblica* powder at concentration of 50g/L and the treatment is for a period of 30 days. The physicochemical and biological parameters were checked before and after treatment.

Results

The results revealed that physical character of BDU water samples collected from ten different sites reminded more or less same ie. the samples were colourless, odourless, and tasteless. The pH ranges between 7.2 to 7.6. The temperature of the samples remained at 32^{o}C (Table 2). After treatment with *Phyllanthus emblica* (50g/l for 30 days) there was no appreciable change in colour, odour, taste, temperature and pH and they remaind the same (Table 2). On the other hand there was a change in chemical characters like acidity, alkalinity, total hardness, calcium, magnesium, chloride, nitrate, phosphate and sulphate (Table 3). The acidity ranges between 183 – 366 mg/l before treatment. The sample collected from BD BW was less acidic (183 mg/l) and the acidity was high in AB BW and CDE BW (366 mg/l). On the other hand the alkalinity vary between 516 – 800 mg/l before treatment and GD BW and GD S samples were less alkaline (516mg/l) and BD BW was more (800 mg/l) alkaline.

Total hardness range was 173 – 380 mg/l. GD BW was less hard when compared to all other samples. CDE BW was maximum hard before treatment. Minerals like calcium, magnesium, chloride were also more. There was a minimum change in nitrate, phosphate and sulphate content of all the samples (Table 3).

Compared to the BIS the pH of the water samples analyzed was within the limit. Alkalinity, total hardness, calcium and magnesium content of the samples were too high and chloride, nirate and sulphate was less than that of BIS. As the total hardness of the samples collected was beyond the limit the water samples were treated with plant product *Phyllanthus emblica.*

The acidity of water was enhanced when the water samples were treated with *Phyllanthus emblica* (Table 4). But there was a slight change in the alkalinity of the samples after treatment with *Phyllanthus emblica.* Total hardness was reduced in AB BW, GD BW, H BW, H S, Q B, CDE BW after treatment with *Phyllanthus emblica* and it was totally nil in AS, GDS, QS and BD BW. Similarly chloride level was also reduced due to *Phyllanthus* emblica treatment in samples like AB BW, H BW, HS and CDE BW. There was no chloride in the rest of the samples. Whereas minerals like calcium, magnesium and salts like nitrate, phosphate and sulphate were totally removed in samples treated with *Phyllanthus emblica* (Table 4).

Bacterial population was there in all the samples before treatment and were rod shape. The population of Gram positive bacteria was more than Gram negative (Table 5). After treatment with *Phyllanthus emblica* bacterial population was reduced to a greater extent (Table 6). Some of the water samples collected do had fungal contamination in both treated and untreated (Table 7 & 8) and the treatment does not have any effect on fungal load.

Discussion

The present investigation was carried out to analyse the ground water quality of ten different samples of Bharathidasan University campus, Tiruchirappalli, Tamil Nadu, India which were used for drinking purpose and domestic use. Various physico chemical parameters like colour, odour, taste, temperature, pH, acidity, alkalinity, total hardness, calcium, magnesium, chloride, nitrate, phosphate, sulphate and biological parameters such as bacteria and fungi were examined. The results were compared with standard values prescribed by the Bureau of Indian Standard (BIS). The higher level of some physico chemical parameters such as alkalinity, total hardness and chloride are not desirable for domestic use and may have ill effect and therefore an attempt was made in this study to reduce these parameters using bioproduct.

Phyllanthus emblica wood, a natural product of biological origin was selected in this study to reduce the hardness and biological impurities, as it is commonly practiced for drinking water treatment in rural areas in India and in many African countries (Olayemi and Alabi 1994).

Pure water is colourless but it takes colour, when foreign substances such as organic matter of soil, vegetation, minerals and aquatic organisms are present along with it. Most of the trade wastes discharged into water system have pronounced colours due to organic dyes and inorganic complexes (Spellman, 2003). Coloured water is not aesthetically acceptable to the general public and luckily all our samples were colourless. Similar results have been reported by Freeda et al., (2001) and Meen et al., (2009).

Odour of water is caused both by chemical agents like hydrogen sulphide, free chlorine, ammonia, phenols, alcohols, esters, hydrocarbons and biological agents such as algae, fungi and other microorganisms (Sharma, 2000). All the BDU samples collected and analysed were odourless. Similar result was showed by Bindhu and Selvamohan (2009).

Unpleasant earthy or musty taste and odour are produced by industrial effluent containing iron, manganese, free chlorine, phenols and aquatic actinomycetes. The decomposed organic matter, algae, fungi, bacteria and pathogens impart peculiar taste (Sharma, 2000). But all the samples of this study were tasteless which was in line with Meena et al., (2009). Based on the physical characteristics of the water samples analyzed it may be concluded that the BDU water samples are recommended for potable purposes.

pH is a measure of the hydrogen ion concentration, or more precisely the hydrogen ion activity. The desirable pH range of drinking water given by BIS is 6.5 – 8.5. The pH of this study samples was within the accepted level and hence are potable.

Acidity may also arise due to the presence of mineral acids produced by the hydrolysis of salts of certain heavy metals such as $FeCl_2$ or Al_2 (So_4) (Vermani and Narula, 1989). There is no limit for acidity as per BIS, but it is indirectly controlled by the limits of pH values. The acidity of this study samples were between 183 – 366 mg/L before treatment and 450 – 666 mg/l after treatment.

Alkalinity is the measure of water's ability to neutralize acids or an expression of buffering capacity (Spellman, 2003). In this study, the alkalinity of all the samples exceeded the standard range. It may be due to the discharge of unwanted waste water and seepage from nearly water bodied and the dissolution of carbonates and bicarbonates. Though values of alkalinity of water of all the samples were so high before treatment, there was a little reduction of it after treatment.

Hardness, especially with the presence of magnesium sulphate can lead to the development of laxative effect on new consumers and cause scaling in pipelines. Calcium salts tend to cause incrustations on cooking utensils and water heaters. Hence it is essential to soften the portable water (Spellman, 2003). Calcium is an essential element and human body requires it. Calcium is essential for normal plant growth after and is desirable in water for irrigation (Manivasakam, 1985). Though the samples of CDE BW, H BW and H S showed high total hardness, the calcium levels were within the standard and hence there is no there was no need for its removal.

Magnesium is an essential element for human beings and is relatively non toxic to human. It is essential for normal plant growth also (Manivasakam, 1985). All the samples

under the study were suitable for drinking, since the level of magnesium does not exceed the standard level and hence the samples need not be treatment for magnesium.

Chloride is a common constituent of all natural water and is generally not classified as harmful constituent (Jayanta Chutia and siba Prasad Sarma, 2009) and it is the indicator of contamination with animal and human waste. All the samples of this study had the chloride levels within the limit before treatment with *Phyllanthus emblica* and in some samples it was reduced after treatment and in some cases it was totally removed.

Large amount of nitrate in drinking water is reported to be the cause for methamoglobinemia, a blood disorder which affects the infants under six months of age in particular. Researchers have also linked nitrate to stomach cancer, birth defects, hypertension, enlarged thyroid gland and lymphoma (Howard and Donald, 1985). In this study the samples analyzed had nitrate within the BIS limit and it was disappeared after treatment with *Phyllanthus emblica*.

In aquatic environments, phosphorous is found in the form of phosphate. Major sources of phosphorous include phosphates in detergents, fertilizer and municipal waste water discharges (Sharma, 2000). The phosphorus content of this study samples were lower than that of BIS level before treatment and it went off after treatment with *Phyllanthus emblica*.

Sulfur is required for the synthesis of proteins. The sulphate ions occurs naturally in most water supplies and is also present in waste water. Hydrogen sulphide in interceptor system can cause severe corrosion to pipes. In certain concentrations, it is also a deadly toxin, (Spellman, 2003). The sulphate content of all the samples of this study were well below the BIS values and disappeared after treatment with *Phyllanthus emblica*.

BDU water samples were treated with *Phyllanthus emblica* and the bacterial and fungal population were analyzed and the results revealed that the bacterial and fungal load was reduced after treatment with *Phyllanthus emblica*. The reduction observed in the bacterial population of water treated with *Phyllanthus emblica* wood can be attributed by the antibacterial properties of the bioactive ingredient (Olayemi and Alabi, 1994). A number of bioactive agents that have been isolated from different parts of the *Phyllanthus emblica* may account for the reduction of microbial load.

Conclusion

Overall results of the present study revealed that all the BDU water samples analyzed had higher alkalinity, total hardness and chloride content and was beyond the BIS standard values. The treatment of water using natural product *Phyllanthus emblica* wood resulted in the reduction of total hardness, bacteria and fungi. *Phyllanthus emblica* was effective in the removal of chemical impurities from the water samples and was effective in the inhibition of bacterial contamination. Since, the natural products are of low cost and are easily available they can be used to soften the water.

From this study it can be concluded that the *Phyllanthus emblica* treatment is suitable for the removal of chemical impurities and microbial contaminations like bacteria.

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Table 2 Physical characters of BDU water samples

S.No	Sample Code	Physical Characters before treatment					Physical Characters after treatment with *Phyllanthus emblica*				
		Colour	Taste	Odour	Temp.	pH	Colour	Taste	Odour	Temp.	pH
1	AB BW	Colourless	Tasteless	odourless	32 °C	7.2	Colourless	Tasteless	odourless	32 °C	7.3
2	A S	Colourless	Tasteless	odourless	32 °C	7.2	Colourless	Tasteless	odourless	32 °C	7.4
3	GD BW	Colourless	Tasteless	odourless	32 °C	7.4	Colourless	Tasteless	odourless	32 °C	7.4
4	GD S	Colourless	Tasteless	odourless	32 °C	7.4	Colourless	Tasteless	odourless	32 °C	7.5
5	H BW	Colourless	Tasteless	odourless	32 °C	7.5	Colourless	Tasteless	odourless	32 °C	7.5
6	H S	Colourless	Tasteless	odourless	32 °C	7.4	Colourless	Tasteless	odourless	32 °C	7.5
7	Q B	Colourless	Tasteless	odourless	32 °C	7.4	Colourless	Tasteless	odourless	32 °C	7.4
8	Q S	Colourless	Tasteless	odourless	32 °C	7.5	Colourless	Tasteless	odourless	32 °C	7.5
9	BD BW	Colourless	Tasteless	odourless	32 °C	7.5	Colourless	Tasteless	odourless	32 °C	7.6
10	CDE BW	Colourless	Tasteless	odourless	32 °C	7.6	Colourless	Tasteless	odourless	32 °C	7.5

Table 3 Chemical characters of BDU water samples – Before treatment

S.No	Sample Code	Chemical characters								
		Acidity (mg/l)	Alkaliniy (mg/l)	Total Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Sulphate (mg/l)
1	AB BW	366	666	280	57	54	218	0.6	0.00006	2.6
2	A S	303	550	186	65	29	78	0.6	0.00025	2.6
3	GD BW	266	516	173	62	27	65	0.7	0.00006	2.6
4	GD S	286	516	180	59	29	112	0.6	0.00011	2.9
5	H BW	323	566	333	62	65	209	0.8	0.00005	2.9
6	H S	300	716	333	81	129	157	0.8	0.00009	2.4
7	Q B	216	683	200	65	64	96	0.7	0.00025	2.9
8	Q S	250	700	246	95	51	97	0.8	0.00003	2.9
9	BD BW	183	800	213	57	90	146	0.6	0.00007	2.4
10	CDE BW	366	683	380	69	206	245	0.6	0.00003	2.6

Table 4 Chemical characters of water samples treated with *Phyllanthus emblica*

S.No	Sample Code	Chemical characters								
		Acidity (mg/l)	Alkaliniy (mg/l)	Total Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Sulphate (mg/l)
1	AB BW	566	666	240	-	-	120	-	-	-
2	A S	666	600	-	-	-	-	-	-	-
3	GD BW	470	466	160	-	-	-	-	-	-
4	GD S	553	500	-	-	-	-	-	-	-
5	H BW	570	533	300	-	-	100	-	-	-
6	H S	500	616	273	-	-	100	-	-	-
7	Q B	466	580	200	-	-	-	-	-	-
8	Q S	506	566	-	-	-	-	-	-	-
9	BD BW	533	700	-	-	-	-	-	-	-
10	CDE BW	450	600	200	-	-	130	-	-	-

Note: - = Nil

Table 5 Bacteriological population of water samples before treatment

S.No	Sample code	No of bacterial colonies	No of isolates	Gram's nature		Shape	
				Positive	Negative	Bacilli	Cocci
1	AB BW	TNTC	10	1	3	1	2
2	A S	17	11	2	2	3	0
3	GD BW	33	15	1	2	5	0
4	GD S	TNTC	20	2	0	2	0
5	H BW	TNTC	12	2	1	3	1
6	H S	56	30	2	1	5	0
7	Q B	5	1	2	0	2	0
8	Q S	43	21	3	0	3	0
9	BD BW	7	5	2	0	2	0
10	CDE BW	30	12	3	1	2	0

Note: TNTC = Too Numerous to count

Table 6 Bacteriological population of water samples after treatment with *Phyllanthus emblica*

S.No	Sample code	No of bacterial colonies	No of isolates	Gram's nature		Shape	
				Positive	Negative	Bacilli	Cocci
1	AB BW	21	10	5	1	2	0
2	A S	19	7	5	0	1	0
3	GD BW	12	5	2	2	2	0
4	GD S	7	3	0	1	0	1
5	H BW	5	0	0	0	1	2
6	H S	3	2	1	1	0	0
7	Q B	5	3	2	0	1	1

8	Q S	9	4	0	0	0	0
9	BD BW	7	2	1	0	1	0
10	CDE BW	4	1	0	0	0	0

Table 7 Fungal population of water samples before treatment

S.No	Sample code	No of fungal colonies	Colony morphology
1	AB BW	3	Dark green colour, round colonies
2	A S	-	-
3	GD BW	1	Grass green colour colony
4	GD S	1	Grass green colour round colony
5	H BW	-	-
6	H S	-	-
7	Q B	1	White spongy, round colony
8	Q S	-	-
9	BD BW	1	White spongy, round colony
10	CDE BW	1	White puffy, round colony

Table 8 Fungal population of water samples after treatment

S.No	Sample code	No of fungal colonies	Colony morphology
1	AB BW	3	Dark green colour, round colonies
2	A S	-	-
3	GD BW	1	Grass green colour colony
4	GD S	1	Grass green colour round colony
5	H BW	-	-
6	H S	-	-
7	Q B	1	Dark green colour, round colonies
8	Q S	-	-
9	BD BW	1	White spongy, round colony
10	CDE BW	1	White puffy, round colony

Table 9 Bureau of Indian Standard) Values for the drinking water (BIS)

S.No	Parameters	Values
1	Colour	-
2	Odour	Nil
3	pH	6.5 – 8.5
4	Acidity	-
5	Alkalinity (mg/l)	50 – 200
6	Total hardness (mg/l)	300
7	Calcium (mg/l)	200
8	Magnesium (mg/l)	100
9	Chloride (mg/l)	250
10	Nitrate (mg/l)	20
11	Phosphate (mg/l)	-
12	Sulphate (mg/l)	400