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Assessment of Potability of Drinking Water During Rainy Season in Vellore District, Tamil Nadu, India

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Abstract: Drinking water is a vital resource for all human beings and the access to safe and clean drinking water is a major concern throughout the world. Producing potable water from surface water or ground water usually involves one or several treatment steps for removing unwanted substances. When surface water is used as raw water, turbidity removal is often an essential part of the treatment process. In order to make clean water an available resource for as many people as possible, cheap, simple, robust and efficient process methods are necessary. In this world the amount of resources available to living creatures are limited. The present study was aimed to assess the potability of Drinking water during the Rainy season in five different locations of Vellore district, Tamil Nadu, India. The physico-chemical characteristics of Drinking water samples which are collected from different locations of Vellore district were analyzed. The physico-chemical characteristics of the water are within the permissible limit of Standard provided by TNPCB except the Fluoride content. The water samples does not contain any harmful bacteria such as Enteric coliform which is very dangerous to human health and a main causative agent for many Water borne diseases. But, the water collected from these five locations shows presence of little number of bacterial populations which are not harmful and it may be beneficial to the living organism.

Key words: Rainy Season · Drinking Water · Physico-Chemical Characteristics · Water Potability and MPN Technique

INTRODUCTION

Drinking water is a vital resource for all human beings and the access to safe and clean drinking water is a major concern throughout the world. Producing potable water from surface water or ground water usually involves one or several treatment steps for removing unwanted substances. When surface water is used as raw water, turbidity removal is often an essential part of the treatment process. In order to make clean water an available resource for as many people as possible, cheap, simple, robust and efficient process methods are necessary. These coagulants are used for various purposes depending on the chemical characteristics of the water to be treated. Aluminium salts are by far the most widely used coagulant in water and wastewater treatment. In this world the amount of resources available to living creatures are limited. About 75 % of the present world population lives in the developing countries of the world. About 1.2 billion people still lack safe drinking water and more than 6 million children die from diarrhea in developing countries every year [1].

The bacteriological quality has a large effect on the taste and smell of the water and can sometimes be a large problem in river waters. Eutrophication of the waters due to disposal of phosphorous from agriculture and

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wastewater, among others, favours algae and bacteria growth and can cause health risks.The harmful and dangerous water born disease are caused by pathogenic microorganisms that most commonly are transmitted in contaminated fresh water. Infection commonly results during bathing, washing, drinking, in the preparation of food. Various forms of waterborne diarrheal disease probably are the most prominent examples and affect mainly children in developing countries. Bacteria in waters can cause illnesses as Typhoid (*Salmonella typhi*), Cholera (*Vibrio cholerae*) and Diarrhea (*Giardia lamblia*). Fecal coliforms and *Streptococcus*sp. indicate that wastes from humans or animals contaminate the water. Fecal *Streptococci* are the most resistant group of bacteria and are often analyzed together with total coliforms as an indication of a total bacteriological status. Coliform bacteria can be removed from the water by Chlorination.

Current operational procedures at many treatment works in developing countries are based on arbitrary guidelines, particularly in relation to the dosage of chemicals [2]. Because, they lack knowledge of proper drinking water treatment and they cannot afford costly chemical coagulants. To overcome chemical coagulant problems it is necessary to increase the use of natural coagulants for drinking water treatment. Naturally occurring coagulants are usually presumed safe for human health. Even in the highly industrialized countries, several children still die of water borne diseases.

Emam *et al*. [3] evaluated the quality of drinking water of the valley. A total of 132 drinking water samples were randomly collected from 49 tube wells, 57 wells, 17 taps and 9 stone spouts in different places of California valley. The samples were analyzed for microbiological parameters. Total plate and coliform count revealed that 82.6 % and 92.4 % of drinking water samples found to cross the WHO guideline value for drinking water. During the study, 238 isolates of enteric bacteria were found. Irfan Rashid Sofi *et al.* [4] identified that the *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Acinetobacter radioresistens* and *Pseudomonas aeruginosa*. The water isolates showed optimum growth at 30°C and pH 7.0.Industrial wastes are discharged into water bodies without any treatment contains large amount of organic matter and also contaminants as petroleum hydrocarbons, acids, alkalis and dyes.

Every year about 1.6 million children die because of water borne diseases. The seasons have an important connection with the microbial contamination of water [5]. Thermotolerant coliform is a type of bacteria which act as a microbial quality indicator of drinking water. Other bacteria such as *Klebsiella, Enterobacter cloacea* are present in the water [6]. Water is treated with chlorine along with sodium or calcium hypochlorite to make it fit for drinking [7]. It was estimated that House hold Water Treatment (HWT) can reduce Diarrhoea by 30-40 % [8]. Most frequently used house hold water treatment is using the boiled water for drinking purpose but very effective results is shown in using ceramic and bio-sand household water filters. They have the highest potential in improving the quality of water and in decreasing the water borne diseases and death [9]. The present study was aimed to assess the potability of Drinking water during the Rainy season in five different locations of Vellore district, Tamil Nadu, India.

MATERIALS AND METHODS

Locations Selected for the Sampling of Drinking Water: Five different locations in Vellore district was selected for the collection of Drinking water samples. The selected locations are: Ambur, Jolarpet, Tirupattur, Vaniyambadi and Vengalaburam.

Collection of Drinking Water Samples: Drinking water samples was collected in clean sterilized bottles from water source in Vellore district of Tamil Nadu after the tap was allowed to run for 5 minutes. After sampling of Drinking water samples, the collected samples were transported to laboratory for physico-chemical and microbiological testing. The sampling of Drinking water was done in Rainy season (June 2018 to September 2018).

Analysis of Physical characteristics of Drinking water

Colour: The colour of the collected Drinking watersamples was observed visually.

Odour: The odour of the collected Drinking watersampleswas categorized as pleasant or unpleasantby direct smelling of the sample.

Temperature: The temperature of the Drinking watersamples were noted using Thermometric method at the site of sampling using portable calibrated mercury thermometer.

pH: The pH of the Drinking watersamples was determined by Potentiometric method using pH meter already standardized by using buffer solutions of known value before analysis.

Electrical Conductivity (EC): Electrical conductivity of the Drinking water samples was determined by conductivity meter following the procedure of Richard [10].

Total Suspended Solids (TSS): Total suspended solids are (TSS) of the Drinking water samples was determined by using following formula of Anon [11].

TSS mg/L = (Final wt - Initial wt)/Amount of sample taken × 1000

Total Dissolved Solids (TDS): Total dissolved solids (TDS) of the Drinking watersamples were determined following the procedure of Richard [10] by using Electrical Conductivity (EC) meter.

TDS (mg/L) = EC ìs/cm × 0.67

Total Hardness: For the analysis of Total hardness in Drinking watersamples, 25 ml of sample was diluted to 50 ml with distilled water. A volume of 1 to 2 ml of buffer was added to give a pH of 10.0 to 10.1. One to two drops of indicator solution was added and titrate with EDTA titrant to change in colour from reddish tinge to blue. A sample volume that requires less than 15 ml EDTA titrant was selected and complete titration will be done within 5 min after buffer addition. The EDTA titrant was standardized against standard calcium solution using the above procedure.

Total Hardness (mg $CaCO_3$/L) = A × B × 1000/ ml sample

where,
A = ml EDTA titrated for sample; B = mg $CaCO_3$ equivalent to 1 ml EDTA titrant

Estimation of Biological Oxygen Demand (BOD): The Biological Oxygen Demand (BOD) of the Drinking watersamples was estimated by Winklers Iodometric method [12].

Estimation of Chemical Oxygen Demand (COD): The Chemical Oxygen Demand (COD) of the Drinking watersamples was estimated by Titrimetric method [12].

Analysis of Chemical characteristics of Drinking water
Estimation of Calcium and Magnesium: The Calcium and Magnesium content of the Drinking watersamples was estimated by EDTA Titrimetric method [12].

Estimation of Chloride: The Chloride content of the Drinking water samples was estimated by Silver nitrate Titrimetric method [13].

stimation of Sodium and Potassium: The Sodium and Potassium content of the Drinking water samples was estimated by Flame photometric method [13].

Estimation of Sulphate: The Sulphate content of the Drinking water samples was estimated by Turbidimetric method [12].

Estimation of Nitrogen: The Nitrogen content of the Drinking water samples was estimated by Titrimetric method [12].

Estimation of Phosphorus: The Phosphorous content of the Drinking water samples was estimated by Spectrophotometry method [13].

Estimation of Zinc, Iron, Copper, Lead, Chromium and Manganese: The presence of Zinc, Iron, Copper, Lead, Chromium and Manganese in the Drinking watersamples were estimated byAtomic Absorption Spectrophotometric (AAS) method.

Enumeration of Bacterial Population in Drinking Water: The bacterial population in the collected Drinking water samples will be enumerated in the Standard Plate Count Agar plates by Standard Plate Count (SPC) method. The Drinking water sample collected from five different locations of Vellore district was serially diluted upto 10^{-6} dilution to determine the bacterial population. A volume of 0.1 ml from the sample dilutions (10^{-4} and 10^{-5}) were spreaded (Spread plate technique) on sterile petriplates containing Standard Plate Count Agar for the growth of bacterial colonies at 37°C for 24 hrs. The numbers of bacterial colonies in the Standard Plate Count Agar plates were counted and calculated by using the formula:

cfu/ml = Number of colonies counted/Amount of sample taken × Dilution factor

Determination of Potability of Drinking water by Most Probable Number (MPN) Technique: The Most Probable Number (MPN) Technique was used to check the potability of the collected Drinking water. The MPN technique contains three steps *viz*., a) Presumptive test, b)Confirmed test andc) Completed test.

Presumptive Test: Presumptive test involves the primary presumption for the presence of Gram negative coliform bacteria in the samples demonstrated by the appearance of gas in the Brilliant Green Lactose Broth (BGLB). For the presumptive test procedure, 15 sets of test tubes containing BGLB required for each sample under analysis. Each test tube contained 10 ml of BGLB and inoculated with the water sample in a sequential order of 10 ml in three of each Double Strength BGLB, 1 ml in three of each Single Strength BGLB and lastly 0.1 ml in three of each 10 ml Single Strength BGLB. All the test tubes were incorporated with Durham's tubes for detection of gas formation by Gram negative coliform bacteria. Test tubes were incubated in an Incubator at 37°C for 24 hours and 48 hours.

Confirmed Test: Positive samples with the production of gas in the BGLB were selected for the confirmed test procedures to detect the indicator bacteria of fecal origin *Escherichia coli.* The Eosin Methylene Blue (EMB) agar media was used to differentiate other Gram negative coliform bacteria from the *Escherichia coli* by the production of Green metallic sheen in the EMB medium. The presence of Green metallic sheen in EMB confirms the presence the indicator bacteria *Escherichia coli*. One loopful sample from the positive test tubes was inoculated on EMB by streaking and incubated at 37°C for 24 hours and then observed for the production of Green metallic sheen.

Completed Test: From the positive EMB plates showing Green metallic sheen colonies of *Escherichia coli*, the isolated colonies were observed microscopically for their Gram reactions. This was the final stage of the MPN method where in the decision of water quality as potable or non-potable, could be made after confirmation and completion of the study. Finally, the standard biochemical tests were performed to confirm the identification of all the pathogenic isolates found in all the collected drinking water samples.

RESULTS AND DISCUSSION

The present study was aimed to study the effect of seasonal variations on the presence of bacterial coliforms and potability of drinking water which are collected from five different locations of Vellore district *viz*., Tirupattur, Vengalaburam, Jolarpet, Vaniyambadi and Ambur. The research was carried out in three different seasons: (i) Rainy season (June 2018 to September 2018), Autumn (October 2018 to November 2018) and Winter (December 2018 to February 2019). The findings of the present research are discussed here.

Physico-Chemical Characteristics of Collected Drinking Water Samples in Rainy Season: The physico-chemical characteristics of Drinking water samples which are collected from different locations of Vellore district was analyzed in the rainy season (June 2018 to September 2018) and the results were furnished in Table-1. The results of the physical characteristics and chemical characteristics were compared with the Standard values prescribed by Tamil Nadu Pollution Control Board (TNPCB). The physico-chemical characteristics of the water are within the permissible limit of Standard provided by TNPCB except the Fluoride content. The water samples are colourless, odourless and alkaline in pH (6.5 to 7.3). The temperature of the collected water was ranging from 16.6°C to 19.5°C. Other physical characteristics values are ranging from Electrical Conductivity (218 to 240 d Sm^{-1}), Total Suspended Solids (97 to 135 mg/L), Total Dissolved Solids (45 to 65 mg/L), Hardness (153 to 238 mg $CaCO_3$/L), Biological Oxygen Demand (8.2 to 22.8 mg/L) and Chemical Oxygen Demand (62 to 113 mg/L). The recorded value ranges for Chemical parameters in collected drinking water are, Calcium (13 to 35 mg/L), Fluoride (1.3 to 2 mg/L), Sodium (165 to 198 mg/L), Potassium (55 to 91 mg/L), Sulphate (5.62 to 8.02 mg/L), Nitrate (15.5 to 28.5 mg/L), Phosphorous (5.1 to 7.5 mg/L), Zinc (0.003 to 0.009 mg/L), Iron (0.04 to 0.08 mg/L), Copper (0.004 to 0.008 mg/L), Lead (0.003 to 0.009 mg/L), Magnesium (21.74 to 34.85 mg/L) and Chromium (0.002 to 0.008 mg/L). It was observed that, except Fluoride content all the physico-chemical parameters are within the permissible limit of TNPCB. So, physico-chemically, the water does not contain any hazardous contents which are injurious to health.

Enumeration of Bacterial Population in Collected Drinking Water Samples During Rainy Season: The population of bacteria in the Drinking water collected in Rainy season (June 2018 to September 2018) from different location was enumerated and the results were furnished in Table-2. The bacterial colonies are counted in two dilutions (10^4 and 10^5) by using Quebec Colony Counter and the results are expressed as Colony forming unit/ml (cfu/ml). The highest bacterial population was recorded at 10^4 dilution when compared to 10^5 dilution. Highest bacterial population was recorded in Vaniyambadi (72×10^4 cfu/ml) followed by Jolarpet (66×10^4cfu/ml),

Table 1: Physico-chemical characteristics of collected drinking water samples in Rainy season (June 2018 to September 2018)

Physico-chemical properties	Tirupattur	Vengalaburam	Jolarpet	Vaniyambadi	Ambur	Standard by TNPCB
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Temperature (°C)	17.2	16.6	17.9	19.5	18.3	40
pH	6.5	6.8	7.1	7.3	7.2	5.5-9.0
EC (d Sm^{-1})	220	218	226	240	234	1500
TSS (mg/L)	108	97	115	135	128	200
TDS (mg/L)	50	45	54	65	61	200
Hardness (mg $CaCO_3$/L)	161	153	175	238	230	250
BOD (mg/L)	12.5	8.2	15.6	22.8	20.3	30
COD (mg/L)	74	62	85	113	98	250
Calcium (mg/L)	16	13	21	35	28	200
Magnesium (mg/L)	13	11	18	30	24	50
Chloride (mg/L)	155	132	173	220	190	600
Fluoride (mg/L)	1.7	1.3	1.5	2.0	1.8	1
Sodium (mg/L)	172	165	180	198	193	600
Potassium (mg/L)	68	55	75	91	87	250
Sulphate (mg/L)	6.05	5.62	6.55	8.20	7.90	12
Nitrate (mg/L)	18.3	15.5	22.9	28.5	26.3	600
Phosphorous (mg/L)	5.7	5.1	6.2	7.5	6.9	10
Zinc (mg/L)	0.005	0.003	0.006	0.009	0.008	0.01
Iron (mg/L)	0.05	0.04	0.06	0.08	0.07	0.2
Copper (mg/L)	0.007	0.008	0.006	0.004	0.005	0.01
Lead (mg/L)	0.005	0.003	0.006	0.009	0.007	0.05
Magnesium (mg/L)	25.10	21.74	28.23	34.85	30.23	50
Chromium (mg/L)	0.004	0.002	0.005	0.008	0.006	0.01

EC-Electrical conductivity; TSS-Total Suspended Solids; TDS-Total Dissolved Solids; BOD-Biological Oxygen Demand; COD-Chemical Oxygen Demand; TNPCB-Tamil Nadu Pollution Control Board

Table 2: Enumeration of Bacterial population in collected drinking water samples during Rainy season (June 2018 to September 2018)

Drinking water sample collected Locations	Bacterial population	
	× 10^4cfu/ml	× 10^5cfu/ml
Tirupattur	52	45
Vengalaburam	49	42
Jolarpet	66	52
Vaniyambadi	72	60
Ambur	57	48

cfu-Colony forming unit

Ambur (57 × 10^4 cfu/ml) and Tirupattur (52 × 10^4 cfu/ml). Lowest bacterial population was observed in Vaniyambadi (57 × 10^4 cfu/ml). The population of the bacteria is within the limit so biologically the collected water samples are not injurious to human health.

Presumptive test of MPN Test in Rainy season (June 2018-September 2018): The Drinking water collected in different locations of Vellore district was subjected to Most Probable Number (MPN) Technique and the results are given in Table-3. Unlike the normal MPN Technique, we measured the results in both 24 hours and 48 hours. The Single strength Brilliant Green Lactose Broth (BGLB) tubes (10 ml BGLB + 0.1 ml water sample and 10 ml BGLB + 1 ml water sample) does not shoed any positive reactions but the Double strength Brilliant Green Lactose Broth (BGLB) tubes (10 ml BGLB + 10 ml water sample) has showed the positive reactions in two locations after 24 hours of incubation. Those two locations are, Vaniyambadi and Jolarpet which has showed positive reactions in both 24 hours and 48 hours. The Vaniyambadi water sample has showed MPN Index - 5/100 ml of water after 24 hours incubation and MPN Index - 8/100 ml of water after 48 hours incubation. The water samples collected from Tirupattur, Vengalaburam and Vaniyambadi does not shows positive reaction (no acid and gas production) (MPN Index - <2/100 ml of water) in any MPN tubes in 24 hours. After 48 hours incubation, the water samples collected from Tirupattur (MPN Index - 5/100 ml of water) and Vengalaburam (MPN Index - 8/100 ml of water) has showed the acid production in tubes with yellow colour formation. Surprisingly, the water sample collected from Ambur does not show any positive reactions after 48 hours. The colour change in BGLB was not observed after 24 hours incubation but after 48 hours incubation, the colour change was noticed from green to yellow. It clearly

Table 3: Results of Presumptive test of MPN test in Rainy season (June 2018-September 2018)

S. No	Location	Incubation period	Combination of Positives			* MPN Index/ 100 ml	** 95 % Confidence Limits	
			3 of 10 ml	3 of 1 ml	3 of 0.1 ml		Lower	Upper
1	Tirupattur	24 Hours	0	0	0	<2	-	-
		48 Hours	2	0	0	5	<0.5	13
2	Vengalaburam	24 Hours	0	0	0	<2	-	-
		48 Hours	3	0	0	8	2	22
3	Jolarpet	24 Hours	3	0	0	8	2	22
		48 Hours	3	0	0	8	2	22
4	Vaniyambadi	24 Hours	2	0	0	5	<0.5	13
		48 Hours	3	0	0	8	2	22
5	Ambur	24 Hours	0	0	0	<2	-	-
		48 Hours	0	0	0	<2	-	-

* MPN Index-Referred Standard MPN Table

** 95 % Confidence Limits– Referred Standard MPN Table

All the experiments have been done 3 times and one representative data have been shown.

Table 4: Results of Confirmed test of MPN test in Rainy season (June 2018-September 2018)

S. No	Location	Incubation period	Growth on EMB plate	Production of Metallic sheen on EMB plate	Potability of Drinking water
1	Tirupattur	24 Hours	+	-	Potable
		48 Hours	+	-	
2	Vengalaburam	24 Hours	+	-	Potable
		48 Hours	+	-	
3	Jolarpet	24 Hours	+	-	Potable
		48 Hours	+	-	
4	Vaniyambadi	24 Hours	+	-	Potable
		48 Hours	+	-	
5	Ambur	24 Hours	+	-	Potable
		48 Hours	+	-	

+ :Present and - : Absent

showed that the bacterial population was very low at 24 hours incubation so not showing any colour change but after 48 hours incubation, the bacterial population was increased in the BGLB and colour change was observed.

Confirmed test of MPN test in Rainy season (June 2018-September 2018): The results of Confirmed test of Most Probable Number (MPN) technique in Rainy season (July 2018 to September 2018) was furnished in Table-4. A loopful of sample from the Presumptive test tubes was streaked on the Eosin Methylene Blue (EMB) and incubated in an Incubator at 37°C for 24 hours and 48 hours. After incubation, the EMB plates showed the presence of bacterial colonies but the Green metallic sheen was not observed. Hence, we concluded that the water sample contains the normal bacterial population but not the coliform bacteria *Escherichia coli*. So, the drinking water collected from five different locations of Vellore district are potable to drink.

All the experiments have been done 3 times and one representative data have been shown.

Sofi *et al*. [4] investigated the physical and chemical nature of water samples and showed that the ground water was extremely contaminated with the Total suspended solids. Due to the high concentration of Total dissolved solids, the water loses its drinking portability and also reduces the solubilizing ability of oxygen in water. But in our present study, we did not found such problems in our study area.

Several reports has showed that the drinking water supplied to the residents are frequently contaminated with pathogenic bacteria, broken plastic pipes, leaking sewer lines and poor maintenance of old pipe networks are the primary source of drinking water contamination. These kinds of activities makes the water unfit to drink and the potability of the drinking was estimated by Most Probable Number (MPN) method.

CONCLUSION

The present study concludes that the Drinking water collected in Rainy season (June 2018to September 2018)

from five different locations around Vellore district, Tamil Nadu, India (Ambur, Vaniyambadi, Tirupattur, Jolarpet and Vengalaburam) was potable to drink. These water samples does not contain any harmful bacteria such as Enteric coliform which is very dangerous to human health and a main causative agent for many Water borne diseases. But, the water collected from these five locations shows presence of little number of bacterial populations which are not harmful and it may be beneficial to the living organism water shows variations in Rainy season. So, it is recommended to boil the water for better sanitation and to avoid spreading of Water borne diseases.

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