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Assessment of potability of Drinking water during Rainy season in Tirupattur District, Tamil Nadu, India

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Abstract

All people need access to safe and clean drinking water, which is a huge global challenge. Drinking water is an essential resource for all living things. Surface water or ground water must typically undergo one or more treatment procedures to remove impurities before being converted into drinkable water. The elimination of turbidity is frequently a crucial step in the treatment process when surface water is utilized as the raw water. Cheap, simple, reliable, and effective process methods are required to provide clean water as a resource to as many people as feasible. Living things have a finite number of resources at their disposal in this planet. The purpose of the current study was to evaluate the drinkability of water during the rainy season in five distinct locations in the Tirupattur district of Tamil Nadu, India. Drinking water samples that were obtained from various places in the Tirupattur district were examined for their physico-chemical properties. Except for the fluoride concentration, the water's physico-chemical properties are within the TNPCB-provided permitted limit of Standard. The water samples were free of hazardous bacteria including enteric coliform, which is extremely risky to human health and a major factor in many water-borne illnesses. However, the water gathered from these five sites reveals the presence of a small number of bacterial communities that are not toxic and may even be advantageous to living things.

Key words : MPN Technique, Drinking water, Physico-chemical properties, and Rainy Season.

Water is an essential part of day-to-day life. All living beings in this universe need water for their growth, development and metabolic reactions. On this earth, water contains 71 % of whereas, there are types of water like groundwater, standing water, surface water, and rainwater[12]. But, all the water is not potable for the drinking purpose. According to the statistical analysis by about 98 % of the drinking water which was utilized by human beings was groundwater but day by day the use of ground water as drinking water was gradually reduced due to the entry of various mineral water companies[20]. In earth, fresh water is present in 3 % because water may or may not contain sodium, calcium, magnesium, hydrogen sulphide gas, and sulphur-producing bacteria. So, the water taste will be milky, bitter and salty with rotten egg smell in sometimes. Microbial contamination of water, particularly by the coliform bacteria is very prevalent in current days but its population will be varied according the seasonal variations. If contaminated water was consumed, its results in various diseases and other health issues. Water is the vital source for the human life because of the variety of purposes including, promoting healthy cell activity, regulating metabolism, and helping in digestion. Moreover, it assists in the elimination of waste and toxins from the human body. Compared to adults, infants and toddlers have a higher amount of water in their bodies, making up nearly 60 % of humans[13].

People utilize groundwater for residential use in their homes, agricultural irrigation, and industrial use in Indian states like Tamil Nadu[10]. For household use and irrigation of agricultural crops, people who live in rural parts of India fully rely on groundwater[5]. Seasonal rains, rivers, lakes, streams, wells, and bore wells are the primary sources of water[19]. Drinking water is regularly being contaminated in modern society due to human activities including industrialization, urbanization, poor drainage systems, the direct disposal of industrial pollutants into water bodies without sufficient treatment, as well as the activities of the growing population[8]. All of the aforementioned human activities severely pollute the water sources, rendering them unsafe for consumption[18]. The drainage from industries including chemicals, leather, textile, paper mills, nuclear power plants, and other sectors is the main cause of water pollution in the majority of industrial districts. These elements mainly contribute to the problem of water contamination, which prevents it from being utilized for drinking[6].

Contaminated drinking water is a major source of the spread of many contagious and harmful microbiological illnesses[20,21]. Water borne diseases are infections that are transmitted by the contaminated water by bacteria, virus, protozoa and helminths. Some of the most well-known water borne infections include Amoebiasis (*Entamoeba histolytica*), Giardiasis (*Giardia lamblia*), Malaria (*Plasmodium vivax*), Cholera (*Vibrio cholerae*), Dysentery (*Shigella dysentriae*), Paratyphoid fever (*Salmonella paratyphi*), Typhoid (*Salmonella typhi*) and Jaundice (Hepatitis B virus)[9]. Along with the harmful pathogens, contaminated water also contains some carcinogenic substances such as arsenic, fluorides, lead, and nitrates, which have a severe impact on the health of humans, animals, plants, and aquatic living being[4]. In

some Industrial areas, the generated wastes were disposed into water bodies like sea, river, lake and estuary, without proper treatment and contains a large number of toxins, including petroleum hydrocarbons, heavy metals, acids, alkalis, dyes and recalcitrant xenobiotic compounds[19].

Faecal pollution arise from the domestic and municipal sewage waste is associated with the threat of microbiological contamination of drinking water (particularly with Coliform pathogens)[22]. The majority of the microbial illnesses to the living organisms are linked to faecal contamination of drinking water[15]. According to the recent report of World Health Organization (WHO), more than 5 million people died each year as a result of water borne illnesses. Based on a recent WHO report, approximately 1.6 million children die each year as a result of water-borne infections. The microbiological contamination of drinking water has a meaningful relationship with seasonal changes because climatic conditions is one of the major factors which influences the microbial growth[17].

A particular class of bacteria called coliform can serve as a microbiological quality indicator of drinking water[1]. The majority of coliforms are members of the Enterobacteriaceae family, which includes the majority of intestinal pathogenic bacteria. *Escherichia coli*, a Gram negative, rod shaped, motile bacteria that produce the enzymes catalase and oxidase, is a well-known example of coliform[14]. The water contains other coliform bacteria including *Klebsiella pneumoniae*, *Enterobacter cloacae*, and *Citrobacter* sp., but their presence is not given as much weight as it should be when compared to other coliforms[23]. The quality of the drinking water is examined based on the presence or absence of coliforms[2].

According to estimations, household water purification can cut down on diarrhoea by 30 to 40 %. The most popular residential water treatment method is boiling water for drinking, although utilizing ceramic and bio-sands and residential water filters have been demonstrated to produce highly effective results[22,25]. They have the best chance of enhancing water quality and lowering the number of water-related illnesses and mortality[14]. For large-scale use, drinking water is disinfected using chemicals like chlorine, sodium hypochlorite, or calcium hypochlorite to make it safe to drink[3].

The present study was aimed to evaluate the quality and potability of drinking water in different seasons (Rainy season, Autumn season and Winter season) through Physico-chemical characteristics and Most Probable Number (MPN) Technique. Water samples are collected from five different locations in Tirupattur District, Tamil Nadu, India. The locations which are chosen for the present research are Ambur, Jolarpet, Vaniyambadi, Natrampalli, and Tirupattur. Water samples are collected in three different seasons *viz*., Rainy season, Autumn, and Winter season. The collected Drinking water samples were subjected to Physico-chemical analysis. To check the presence of enteric coliforms and the potability of collected drinking water, the Most Probable Number Technique (MPN) was used as the most common test for checking the potability of the drinking

water. The MPN technique contains three steps (a) Presumptive test, (b) Confirmed test, and (c) Completed test. The results are compared with the MPN Standard Table and the potability of the water was analysed[4]. Due to the use of contaminated water for drinking activities, particularly in developing nations like India, coliform bacteria have the greatest effect on the human body and cause water borne infections. This study is extremely important to our society because, in the event that enteric coliform bacteria are found in significant concentrations during any given season, people will be made aware of the need to take precautions like boiling or chlorinating water to protect from various water based and water related infectious diseases.

Locations chosen for drinking water sample collection :

For the collection of drinking water samples, five distinct locations in the Tirupattur district were chosen. Tirupattur, Natrampalli, Jolarpet, Vaniyambadi, and Ambur are the chosen places.

Collection of Drinking water samples :

The drinking water samples was collected in clean sterilized bottles from the water source in the Tirupattur 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 the laboratory for Physico-chemical and microbiological testing. The sampling of Drinking water will be done in three seasons *viz*., Rainy season (June 2022 to September 2022)[18].

Analysis of Physical characteristics of Drinking water :

Colour :

The colour of the collected Drinking water samples was observed visually.

Odour :

By directly inhaling a sample, the smell of the collected drinking water samples was judged as either pleasant or unpleasant.

Temperature :

Drinking water samples' pH levels were assessed using the potentiometric technique with a pH meter that was standardized with known-value buffer solutions before the analysis.

pH :

Drinking water samples' pH levels were assessed using the potentiometric approach using a pH meter that had been calibrated with known-value buffer solutions prior to analysis.

Electrical conductivity (EC) :

A conductivity meter was used to measure the electrical conductivity of drinking water samples following the procedure of Richard *et al*.[13].

Total suspended solids (TSS) :

The total suspended solids (TSS) of the Drinking water samples were calculated by using the below given formula.

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

Total Dissolved solids (TDS) :

Using an Electrical conductivity (EC) meter, the Total dissolved solids (TDS) of drinking water samples were measured in accordance with Richard *et al*. [13].

$$TDS\ (mg/L) = EC\ \mu s/cm \times 0.67$$

Total Hardness :

Using distilled water to dilute the sample from 25 ml to 50 ml, the total hardness in drinking water samples was examined. The pH was increased from 10.0 to 10.1 by adding 1 to 2 ml of buffer. The indicator solution was added in one to two drops, and the process was followed for titration.

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

Where,

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

Estimation of Biological Oxygen Demand (BOD) :

Winkler's iodometric technique was used to assess the drinking water samples' Biological Oxygen Demand (BOD)[2].

Estimation of Chemical Oxygen Demand (COD) :

The Chemical Oxygen Demand (COD) of the Drinking water samples was evaluated by the Titrimetric method[2].

Analysis of Chemical characteristics of Drinking water :
Estimation of Calcium and Magnesium :

By using the EDTA Titrimetric technique, the Calcium and Magnesium content of the drinking water samples was calculated[2].

Estimation of Chloride :

The Silver Nitrate Titrimetric technique was used to quantify the chloride level of the drinking water samples[5].

Estimation of Sodium and Potassium :

By using the flame photometric technique, the sodium and potassium content of drinking water samples was calculated[5].

Estimation of Sulphate :

By using the turbidimetric approach, the sulphate content of drinking water samples was evaluated[2].

Estimation of Nitrogen :

The Titrimetric approach was used to assess the Nitrogen level of water samples[2].

Estimation of Phosphorus :

Using spectrophotometry, the phosphorus concentration of drinking water samples was calculated[5].

Estimation of the elements (Zinc, Iron, Copper, Lead, Chromium and Manganese):

The Atomic Absorption Spectroscopy (AAS) method was used to evaluate the levels of Zinc, Iron, Copper, Lead, Chromium, and Manganese in drinking water samples[11].

Enumeration of Bacterial population in Drinking water :

The Standard Plate Count (SPC) technique was used to count the bacteria in the collected drinking water samples on Standard Plate Count Agar plates. To measure the bacterial population, the drinking water sample was serially diluted up to a 10^{-6} dilution at five separate locations within the Tirupattur locations. A volume of 0.1 ml from the sample dilutions (10^{-4} and 10^{-5}) was distributed (Spread plate technique) on sterile Petri plates containing Standard Plate Count Agar for the development of bacterial colonies at 37 °C for 24 hours. The following formula was used to count and determine the bacterial colony counts on the Standard Plate Count Agar plates:

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

Water potability is determined using the Most Probable Number (MPN) method:

To determine if the water that had been collected was potable, the Most Probable Number (MPN) Technique was applied. The MPN technique contains three steps *viz*., a) Presumptive test, b) Confirmed test and c) Completed test[7].

Presumptive test :

By the appearance of gas in the Brilliant Green Lactose Broth (BGLB), the Gramme negative coliform bacteria are first and foremost presumed to be present in the samples in a presumptive test. Three sets of test tubes (15 Test tubes) containing BGLB were needed for the hypothetical test process for each sample being analysed. Each test tube had 10 ml of BGLB in it, and the water sample was inoculated into each test tube in the following order: 10 ml in three of the Double Strength BGLB, 1 ml in three of the Single Strength BGLB, and finally 0.1 ml in three of the 10 ml Single Strength BGLB. Durham's tubes were added to all the test tubes to detect the production of gas by Gram negative coliform bacteria. For 24 and 48 hours, test tubes were incubated in an incubator set to 37 °C [7].

Confirmed test :

For the verified test techniques to find the indicator bacteria of faecal origin *Escherichia coli*, positive samples with gas generation in the BGLB were chosen. By producing a green metallic sheen in the Eosin Methylene Blue (EMB) medium, additional Gramme negative coliform bacteria were distinguished from *Escherichia coli*. The presence of the indicator bacterium *Escherichia coli* was confirmed by the Green metallic sheen found in EMB. After streaking one loopful of the positive sample onto an EMB surface and incubating it there for 24 hours at 37 °C, the result was checked for the appearance of a Green metallic sheen[7,20].

Completed test :

Escherichia coli colonies with a green metallic sheen on positive EMB plates were isolated colonies, and their Gramme responses were examined under a microscope. After study completion and confirmation, this was the step of the MPN technique when the choice of whether the water was drinkable or not could be made. In order to validate the identity of all the pathogenic isolates discovered

in all the collected drinking water samples, the usual biochemical tests were lastly carried out[7].

The current study's objective was to examine how seasonal fluctuations in water quality affected their potability in five distinct Tirupattur district locations: Tirupattur, Natrampalli, Jolarpet, Vaniyambadi, and Ambur. The three seasons of rainy (June 2022 to September 2022), autumn (October 2022 to November 2022), and winter (December 2022 to February 2023) were used to perform the research. The results of the current study are given below.

Physico – chemical characteristics of collected Drinking water samples in Rainy season :

The Physico-chemical characteristics of the drinking water collected from different places in the Tirupattur district were examined during the Rainy season (June 2022 to September 2022) and the results were displayed in Table -1. The result of the Physical and Chemical characteristics was compared with the Standard values fixed by Tamil Nadu Pollution Control Board (TNPCB). The collected water sample's physico-chemical properties are within the Standard values except Fluoride content. The drinking water samples have a pH range of 6.4 to 7.5 and are colourless, odourless, and alkaline. Temperatures of the collected drinking water ranged from 17.1 °C to 19.8 °C. Biological oxygen demand (9.8 to 23 mg/L) and chemical oxygen demand (65 to 115 mg/L) are other physical characteristic values. Electrical conductivity (220 to 245 d Sm^{-1}), total suspended solids (98 to 134 mg/L), total dissolved solids (47 to 64 mg/L), hardness (155 to 235 mg $CaCO_3$/L), and total oxygen demand (9.8 to 23 mg/L) are also included. Calcium (15 to 38 mg/L), magnesium (12 to 32 mg/L), chloride (135 to 225 mg/L), fluoride (1.2 to 2 mg/L), sodium (168 to 197 mg/L), potassium (56 to 90 mg/L), sulphate (5.60 to 8.20 mg/L), nitrate (15.4 to 28.6 mg/L), phosphorous (5 to 7.6 mg/L), zinc (0.003 to 0.008 mg/L), iron (0.05 to 0.08). Other from the fluoride concentration, all physico-chemical parameters were said to be within the TNPCB Permitted range. Therefore, there are no dangerous elements in the water that might endanger public health.

Presumptive Test during The Rainy Season (June 2022 - September 2022) :

The findings of using the Most Probable Number (MPN) Technique on drinking water samples gathered from various locations within the Tirupattur district are shown in Table-7. In contrast to the widely used MPN Technique, we looked at the outcomes 24 and 48 hours later. In the samples taken from Jolarpet and Vaniyambadi, 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) demonstrated positive findings (colour change from Green to Yellow with Gas generation). There was no colour shift from green to yellow or gas generation in the other water samples taken from Tirupattur, Natrampalli, and Ambur. After 24 hours of incubation, double strength Brilliant Green Lactose Broth (BGLB) tubes (10 ml BGLB + 10 ml water sample) demonstrated several favourable responses in all five sites. After 24 and 48 hours, gas output at the five locations in Tirupattur, Natrampalli, Jolarpet, Vaniyambadi, and Ambur responded well.

Table-1. Physico-chemical parameters of drinking water samples collected during the rainy season (June 2022 to September 2022)

Physio–chemical properties	Drinking water samples collected from locations					Standard by TNPCB
	Tirupattur	Natrampalli	Jolarpet	Vaniyambadi	Ambur	
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Temperature (^oC)	17.5	17.1	18.5	19.8	18.5	40
pH	6.4	6.7	7.2	7.5	7.3	5.5-9.0
EC (d Sm^{-1})	223	220	225	245	232	1500
TSS (mg/L)	107	98	117	134	126	200
TDS (mg/L)	52	47	55	64	62	200
Hardness (mg $CaCO_3$/L)	165	155	170	230	235	250
BOD (mg/L)	11.8	9.8	16.5	23.0	21.0	30
COD (mg/L)	75	65	90	115	100	250
Calcium (mg/L)	18	15	20	38	30	200
Magnesium (mg/L)	14	12	21	32	26	50
Chloride (mg/L)	152	135	174	225	192	600
Fluoride (mg/L)	1.8	1.2	1.5	2.0	1.9	1
Sodium (mg/L)	175	168	181	197	194	600
Potassium (mg/L)	67	56	74	90	86	250
Sulphate (mg/L)	6.02	5.60	6.54	8.20	7.92	12
Nitrate (mg/L)	18.2	15.4	23.0	28.6	26.5	600
Phosphorous (mg/L)	5.5	5.0	6.1	7.6	6.8	10
Zinc (mg/L)	0.004	0.003	0.005	0.008	0.007	0.01
Iron (mg/L)	0.06	0.05	0.06	0.07	0.08	0.2
Copper (mg/L)	0.006	0.007	0.008	0.005	0.006	0.01
Lead (mg/L)	0.004	0.003	0.005	0.009	0.008	0.05
Manganese (mg/L)	25.15	22.10	28.24	35.10	30.25	50
Chromium (mg/L)	0.004	0.003	0.005	0.007	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 the Rainy season (June 2022 to September 2022)

Locations of Collected Drinking water sample	Bacterial population	
	$\times 10^4$ cfu/ml	$\times 10^5$ cfu/ml
Tirupattur	54	48
Natrampalli	50	44
Jolarpet	68	50
Vaniyambadi	73	58
Ambur	59	47

cfu – Colony forming unit

After 24 hours of incubation, the Tirupattur water sample had an MPN index of 27/100 ml of water. The MPN Index after 48 hours of incubation was 170/100 ml of water. The MPN index for the Natrampalli water sample was 54/100 ml after 24 hours and 540/100 ml after 48 hours of incubation. After 24 and 48 hours of incubation, the Jolarpet water sample exhibits an MPN Index of 280/100 ml of water and 350/100 ml of water, respectively. After 24 hours and 48 hours of incubation, the Vaniyambadi water sample had an MPN Index of 39/100 ml and 350/100 ml, respectively. After 24 hours and 48 hours of incubation, the Ambur water sample had an MPN Index of 54/100 ml and 350/100 ml, respectively. Both after 24 and after 48 hours, the bacterial population, gas generation, and colour changes were noted here.

Table – 3. MPN Presumptive test during the Rainy season (June 2022 - September 2022)

S. No.	Location	Incubation period	Combination of Positive tubes			*MPN Index/ 100ml	**95% Confidence limits	
			5 of 10 ml	5 of 1 ml	5 of 0.1 ml		Lower	Upper
1	Tirupattur	24 hours	4	3	0	27	12	67
		48 hours	5	4	1	170	70	480
2	Natrampalli	24 hours	4	4	3	54	36	153
		48 hours	5	5	2	540	200	2000
3	Jolarpet	24 hours	5	4	3	280	120	690
		48 hours	5	4	4	350	160	820
4	Vaniyambadi	24 hours	4	3	2	39	15	77
		48 hours	5	4	4	350	160	820
5	Ambur	24 hours	4	4	3	54	36	153
		48 hours	5	4	4	350	160	820

* 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.

MPN confirmed test during the Rainy season (June 2022– September 2022) :

The results of the Most Probable Number (MPN) technique Confirmed test during the Rainy season (July 2022 to September 2022) are displayed in Table - 8. Samples from the Presumptive test tubes were taken in loops, streaked on Eosin Methylene Blue (EMB) plate, and incubated for 24 hours and 48 hours in an incubator at 37 °C. The EMB plates showed the existence of bacterial colonies upon incubation however, the Green metallic sheen was not seen. As a consequence, we concluded that the water sample only contains the normal bacterial population and does not contain the coliform bacterium *Escherichia coli*. As a result, the drinking water collected from five different locations in the Tirupattur area is safe to use in the Rainy season.

Table–4. MPN Confirmed test during the rainy season
(June 2022– September 2022)

S. No	Location	Incubation period	Growth on EMB plate	Growth of metallic sheen on EMB plate	Portability of drinking water
1	Tirupattur	24 hours	Positive	Negative	Potable
		48 hours	Positive	Negative	
2	Natrampalli	24 hours	Positive	Negative	Potable
		48 hours	Positive	Negative	
3	Jolarpet	24 hours	Positive	Negative	Potable
		48 hours	Positive	Negative	
4	Vaniyambadi	24 hours	Positive	Negative	Potable
		48 hours	Positive	Negative	
5	Ambur	24 hours	Positive	Negative	Potable
		48 hours	Positive	Negative	

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

Irfan Rashid Sofi[4] looked into the physical and chemical makeup of water samples and demonstrated how seriously polluted with Total suspended solids in ground water. Water loses its capacity to be transported for drinking and loses its ability to dissolve oxygen due to a high concentration of total dissolved solids. However, in our investigation, we did not discover any such issues in the research area. According to Saranraj *et al*. [17], the main causes of drinking water pollution include leaky sewage lines, broken plastic pipes, and inadequate maintenance of ancient pipe networks. The water that is delivered to homes is regularly polluted with dangerous germs. These kind of activities makes the water unfit to drink and the potability of the drinking was estimated by Most Probable Number (MPN) method.

According to the results of the current study, drinking water that was collected throughout the rainy season (June 2022 to September 2022) from five distinct places in the Tirupattur district of Tamil Nadu, India (Tirupattur, Natrampalli, Jolarpet, Vaniyambadi, and Ambur) was safe to consume. These water samples are free of hazardous bacteria including enteric coliform, which is extremely detrimental to human health and a major contributor to many water-borne illnesses. However, the water gathered from these five sites reveals the presence of a small number of bacterial communities that are not toxic and may even be advantageous to living things. Water changes during the rainy season. For improved cleanliness and to prevent the spread of water-borne infections, it is thus advised to boil the water.

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