SARASWAT: The Tripura University Research Journal

Vol. 2, Issue 1, Pp.52-61, DOP: 20-04-2022

WATER QUALITY ASSESSMENT OF DIFFERENT SAMPLES COLLECTED FROM VARIOUS LOCATIONS OF TRIPURA UNIVERSITY CAMPUS AND SELECTION OF APPROPRIATE POINT OF USE WATER PURIFICATION TECHNOLOGY

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Abstract

The present work investigated the water quality from various departments and important buildings of Tripura University campus which are used for various purposes including drinking. The feed water is centrally treated by an Iron Removal Plant before supplying it to all the overhead storage tanks present in the campus which are either used directly for various washing and cleaning purposes or for drinking using either a resin-based filter or a combination of both resin and RO based purifiers. A total of around 36+2 samples were collected from various important locations of Tripura University campus which includes both tap water and drinking water which are used daily by campus dwellers. The additional two samples have been collected from the central Iron Removal Plants which constitutes of the feed stream going into the plant and the product stream coming out of the plant which are supplied to the reservoirs. The samples were analysed with reference to the Bureau of Indian Standards (BIS). The analysis was carried out for pH, turbidity, conductivity, TDS, COD and metals such as iron, calcium and magnesium. The interpretation of the analytical data shows that most of the collected samples met the BIS standards for drinking water except for a few and a comprehensive idea has been presented for selection of a suitable point of use water purifier suitable for the campus.

Keywords: Water quality, Tripura University, Water purification, BIS standards, pH, Turbidity, TDS, Conductivity, Metal Content, Point of use purifier, Campus

Introduction

The importance of clean water containing essential nutrients and the role it plays in the existence of life on the earth is well known to all (Hoekstra et al.). Water is required by each and every system of our body starting from cells and tissues to various vital organs in order to function properly. Water also serves as the sustainable media for plants, animals and aquatic organisms. Humans used to depend mainly on surface water during the ancient times (Davies and Etris). Currently with the ever-increasing amount of human population, the demand for water is sky rocketing and human race started to explore water from underground sources too

(Kertesz et al.). Now with the rise of industries and the discharge of industrial effluents along with domestic and hospital discharges sometimes untreated along with various other anthropogenic activities, the quality of water has started to degrade (Percival and Walker). India is in the list of 3rd worst water quality as per NITI Ayog reports where India stands at 120 out of 122 in the chronology of water quality Index (NITI Ayog) . India is also reported to extract almost 25% of its water needs from underground sources and if the trend goes like this the day in not far when there will be a scarce of underground water (Wada et al.).

As far as Tripura is concerned which is situated in the north-eastern part of India and the third-smallest state in the country which is bordered in three directions by Bangladesh and the Indian states of Assam and Mizoram to the east constitutes to approx. 0.3% of the country's population (Sen et al.). The name Tripura is said to have originated from 'Twi' which means water and 'Para' meaning land. The indigenous population, which is about 32%, refer to Tripura as ‘Twipra’, meaning ‘land of water’ (Yadav). Unfortunately, the current scenario of the state in terms of clean water presents a different picture. Though the annual average per capita water availability in Tripura state is 35,000 litres, which is almost double that of the national average of 18,000 litres yet the people of Tripura are still facing a two-pronged problem - water shortage as well as water-borne diseases. The water shortage is mainly due to large-scale deforestation and degradation of vegetation cover mostly in the hills which have resulted in massive soil erosion thereby leading to the rise of river beds. This means less storage capacity and drainage of excess water to Bangladesh (“Land of Water, No More”). Various reports have indicated that most of the areas from which samples have been collected throughout the state, the problem of excessive iron content specially in groundwater have been observed which requires the usage of Iron Removal Plants (IRP) for making the water potable and further make it suitable for drinking water needs (Singh and Kumar). Moreover there are various other reasons which makes the water unsuitable for drinking and one such reason is that the water obtained are found to be mostly acidic in nature (Singh and Kumar). Some samples also indicated the presence of some heavy metals which may be carcinogenic in the long run (Singh and Kumar).

Though various water purification technologies are now a days available to take care of the point of use water treatment needs, they can vary from resin-based ion-exchange water softeners to RO-UV and UF-UV based purifiers. However, there is very little knowledge or clarification about the appropriate section of the water purifiers which can not only provide pure drinking water but a healthier one which is most important for our body’s day to day physiological activities. There are various instances encountered in day-to-day life when RO water purifier company’s representatives come and suggest a complex and costly RO based water purifier claiming the water obtained from those purifiers are 100% pure and charge a hefty amount compromising the fact that our human body not only needs clean and pure water but also a healthy one.

The current study deals with estimating the Tripura University campus water quality based on various essential paraments for both the feed water (tap water) which is supplied directly from the primary treatment plants present in the campus and stored in overhead reservoirs and also the water which is used for drinking after treating it using point of use water purifiers like resin based water softeners and RO based purifiers and suggesting the appropriate technology for the selection of point of use water purifiers in the campus in addition to the various initiatives one must take to ensure pure and healthy drinking water.

Material and methods

Study area

Various samples have been collected in the month of February 2021 from different locations of Tripura University campus buildings including the water obtained from the IRP plant located near Academic Building 11 and near the Bridge. Dueto the operational and collection limitations, the underground water was collected from the IRP near the Bridge and the treated water was collected from the IRP situated near Academic Building 11. Both the feed water (tap water) samples and the drinking water samples obtained from various campus buildings were analysed for various important parameters and are verified with the permissible limits suggested by BIS. The samples have been collected from almost all of the academic buildings present in the campus including the Library building, Central Instrumentation Centre building, Administrative building and the Pariksha Bhavan building. As it was observed that two different point of use water purifiers viz. only resin-based purifier and resin retrofitted with RO based purifier are currently used in the location of study, special emphasis was given to collect the samples from all such purifiers from a building. If the entire building was found to be using only one type of purifier, only the samples from a particular system present in the same building was considered for study whereas if a building used both the above-mentioned point of use purifiers, the samples from both of those purifiers from the same building was analysed. A total of 34 samples were collected and analysed.

Sample collection

To prevent unusual changes in water quality, samples were gathered in a clean plastic poly-ethylene bottles and taken to the laboratory immediately. All the bottles were washed and rinsed thoroughly with clean deionized water prior to collection.

Analysis

Each of the water samples were collected and analysed for various important and basic parameters such as pH, Turbidity (TDS), Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Magnesium (Mg), Calcium (Ca) & Iron (Fe) contents. The pH was measured using Eutech 2700 pH meter. The TDS and electrical conductivity was measured using Eutech Con700 conductivity meter. The various metallic constituents were analysed using iCE 3000 series Atomic Absorption Spectrophotometer. The COD was measured using Merck TR 320 Spectroquant Thermoreactor.

Results & Discussion

The samples collected from different locations/buildings of Tripura University campus along with the point of filter used is shown in Table 1. The physico-chemical parameters as well as some of the metallic contents of the samples collected from different locations is presented in Table 2 and that the prescribed limit as per BIS standards is presented in Table 3. All of the samples have been tested at room temperature of 20°C.

Table1. Samples collected from various locations of Tripura University campus along with the water source (The drinking water collected directly from the respective coolers connected with the point of use purifeirs)

Sample Number	Location	Type of Sample	Water Source/ point of use purifier used
1	Chemical & Polymer Engineering	Raw Water	Tap water
2	Chemical & Polymer Engineering	Drinking water	Resin cum RO-UV purifier (Model Kent Mineral RO)
3	Rural Studies	Raw Water	Tap water
4	Rural Studies	Drinking water	Resin Purifier
5	Library	Raw Water	Tap water
6	Library	Drinking water	Resin Purifier
7	Administrative Building	Raw Water	Tap water
8	Administrative Building	Drinking water	Resin Purifier
9	Pariksha Bhavan	Raw Water	Tap water
10	Pariksha Bhavan	Drinking water	Resin Purifier
11	Physical Education	Raw Water	Tap water
12	Physical Education	Drinking water	Resin Purifier
13	Botany	Raw Water	Tap water
14	Botany	Drinking water	Resin Purifier
15	Human Physiology/CIC building	Raw Water	Tap water
16	Human Physiology/CIC building	Drinking water	Resin purifier (UV purifier disconnected condition)
17	Physics	Raw Water	Tap water
18	Physics	Drinking water	Resin Purifier
19	Chemistry	Raw Water	Tap water
20	Chemistry	Drinking water	Resin Purifier
21	Management	Raw Water	Tap water
22	Management	Drinking water	Resin Purifier
23	Distance Education	Raw Water	Tap water
24	Distance Education	Drinking water	Resin Purifier
25	Information Technology	Raw Water	Tap water
26	Information Technology	Drinking water	Resin Purifier
27	Kokborok	Raw Water	Tap water
28	Kokborok	Drinking water	Resin Purifier
29	Economics	Raw Water	Tap water
30	Economics	Drinking water	Resin Purifier
31	Zoology	Raw Water	Tap water
32	Zoology	Drinking water	Resin Purifier
33	Central Iron Removal Plant (Near Bridge)	Raw Feed Water	Feed underground water
34	Central Iron Removal Plant (Near Academic Building 11)	Treated Water	Iron Removal Plant cum oxidation and mixing chamber

Fig.2. Physico-chemical parameters along with metallic contents present in the collected samples

Sample Number	EC (µS/cm)	TDS (ppm)	pH	Turbidity (NTU)	Iron (ppm)	Calcium (ppm)	Magnesium (ppm)	COD (ppm)
1	192	96	6.83	3.42	0.0968	7.6894	1.6225	61
2	58.3	29	6.59	0.89	0.0519	2.9869	0.8096	40
3	127.7	63.7	6.60	1.25	0.057	-	-	-
4	117.1	58.6	6.68	0.94	0.0779	-	-	-
5	105.7	52.8	6.85	3.81	0.1275	-	-	-
6	116.6	58.4	6.82	0.81	0.0712	-	-	-
7	108	54.1	6.78	5.37	0.149	6.132	1.4777	39
8	106.1	52.9	6.81	0.2	0.0787	6.3716	1.4766	34
9	115.3	57.6	6.87	1.12	0.1099	-	-	-
10	118.5	59.2	6.74	0.47	0.0879	-	-	-
11	117.1	58.6	6.85	0.57	0.1216	-	-	-
12	112.6	56.2	6.87	0.21	0.109	-	-	-
13	127.4	63.7	6.82	1.8	0.15	-	-	-
14	144.3	72.1	6.88	0.29	0.129	-	-	-
15	120.9	64.3	6.74	3.19	0.1525	-	-	-
16	125.7	62.9	6.85	3.22	0.1405	-	-	-
17	110	54.8	6.82	4.18	0.1755	-	-	-
18	104.5	52.4	6.89	0.74	0.1459	-	-	-
19	129.5	64.6	6.83	2.5	0.2057	-	-	-
20	115.5	55.8	7	0.08	0.1251	-	-	-
21	112.7	56.4	6.89	1.37	0.1929	-	-	-
22	116.3	58.3	6.95	0.25	0.1208	-	-	-
23	127.3	63.7	6.69	6	0.2547	-	-	-
24	118	59.4	6.65	1.12	0.1774	-	-	-
25	110.4	55.3	6.7	1.38	0.1751	-	-	-
26	113.1	56.7	6.83	0.29	0.1469	-	-	-
27	106.7	53.8	6.75	1.76	0.1886	-	-	-
28	108.4	54.5	6.87	0.87	0.163	-	-	-
29	109.7	54.8	6.67	1.14	0.1641	-	-	-
30	110	55.3	6.9	1.17	0.1739	-	-	-
31	114.7	57.5	6.64	40	2.0365	-	-	-
32	111.9	56.2	6.9	0.21	0.1501	-	-	-
33	105.7	52.4	6.34	21.7	0.42	-	-	-
34	118.2	59.2	6.4	0.82	-	-	-	-

Fig.3. Physico-chemical parameters along with metallic contents allowable in drinking water as per BIS standards (BIS).

Parameters	EC (µS/cm)	TDS (ppm)	pH	Turbidity (NTU)	Iron (ppm)	Calcium (ppm)	Magnesium (ppm)	COD (ppm)
Acceptable Limit	800 (max)	500 (max)	6.5 – 8.5	1	0.30	75	30	250

Electrical Conductivity & TDS

Electrical Conductivity (EC) measurements provide an estimate about the total ionic content present in a solution and in many cases, conductivity is linked directly to the total dissolved solids (TDS) (Ahmad and EL-Dessouky). Total Dissolved Solids are solids in water that can pass through a normal filter. TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for life. From Table 2 it can be observed that the IRP plant is able to discharge the treated water in the permissible range (Sample 33 and 34) and the slight increase in the EC and TDS is due to the probable addition of alum/chloride in the mixing chamber to foster cleaning effect as well as to counter microbial contamination during the water supply process. It can also be seen that almost all of the samples met the BIS standards and in most of the drinking water samples (even ones) the TDS/conductivity has decreased when compared to the tap water (all odd ones) to which actually the point of use purifiers is connected proving the efficiency of the purifier in removing some of the dissolved ions present in the tap water. Notable abrupt behaviour has been observed for Samples 6 (Library building) and 16 (Human Physiology Building) when compared to Samples 5 (Library building) and 15 (Human Physiology Building) respectively where it has been found that the drinking water samples contain more dissolved solids. It can be due to the reason that the purifier used is exhausted and may need cleaning/attention. For other samples which also yielded little higher solids content may also need cleaning/attention very soon. It can also be observed that the Sample 2 contained comparatively 30% less TDS content when compared to the tap water i.e., Sample 1 which confirmed that the Resin cum RO-UV based purifier has removed almost 30% of the dissolved solids from it (Chemical & Polymer Engineering Department).

pH

The pH value of any liquid sample indicates the acidic and alkaline nature of the system by measuring of hydroxyl (OH^-) or hydrogen (H^+) ions (Singh et al.). According to BIS standards, the permissible value of pH for drinking water is 6.5 to 8.5 and it can be observed that all of the samples collected from various buildings tested in the same allowable range with the highest pH value of 7 being tested for drinking water Sample 20 (Chemistry Dept.) and the lowest measured (6.59) for drinking water Sample 2 (Chemical and Polymer Engg. Dept). The lower in the amount of pH is dueto the usage of RO based purifier where dueto the probable rejection of some bicarbonates etc. the pH of water generally decreases. Generally drinking water is said to be healthy if its pH is more than 7 and within 8.5 i.e.

alkaline in nature. In that context addition of some suitable alkaline cartridge may be recommended. The pH content of the underground water was however found to be relatively higher acidic in nature.

Turbidity

By turbidity parameter analysis, the optical property of water is examined where light gets scattered due to the presence of inorganic suspended particulate matter in the sample (Singh et al.). It can be seen from Table 2 that the turbidity of the IRP treated water has been brought to acceptable level (0.82 NTU) from an highly undesired level (21.7 NTU) which means the ground water is full of suspended particles and require turbidity removal treatment which is done well by the IRP. It has also been analysed that almost all of the drinking water turbidity has decreased (more clear and clean water) further after treatment with the water purifiers except for the drinking water Sample 16 obtained from the Human Physiology Dept. which clearly indicates the inefficiency of the water purifier used or may be dueto the accumulation of suspended particles inside the water cooler which needs proper cleaning. Though most of the drinking water samples have tested to be less than 1 NTU still some of the drinking water samples whose turbidity has increased slightly may need some attention. Among all the samples the maximum turbidity was found for tap water Sample 7 obtained from Administrative Building which indicates the probable accumulation of inorganic substances (dust/dirt etc.) in the overhead reservoirs or may be faulty water supply line or may be in the secondary storage (water cooler) from which the samples have been collected.

Iron Content

The main sources of iron in natural water are in mineral form obtained from sediments and rocks and from industrial waste, mining etc (Ahmad and EL-Dessouky). Tripura water has tested very high in Iron content and has been proved by many researchers and the same is evident from the Sample 33 which is the underground feed water sent to IRP for treatment. On analysing the tap water sample, it can be clearly said that the IRP plants are currently effective in reducing the iron content to BIS standard levels (reducing from above 0.3 ppm of Fe to below 0.3ppm). The standard value of iron concentration given by BIS which is 0.3mg/l or 0.3ppm to which almost all of the samples tested to be in range. In this present studies highest and lowest values of iron concentration are recorded 2.0365 ppm and 0.0519 ppm in Zoology (Tap water Sample 31) and Chemical & Polymer Engg department (Drinking water Sample 2) respectively. The high value of Iron in Sample 31 may be due to the faulty overhead reservoir or due to faulty water supply channel or unclean water cooler which needs attention whereas the low amount of Iron in the Sample 2 can be attributed to the removal of iron ions from the water by the RO membrane-based water purifier present in the place of study.

Calcium and Magnesium Content

Calcium and magnesium ions are present in a connectable concentration in natural water as carbonates and bi-carbonates which is directly related to water hardness (Singh et al.). It can be seen from Table 2 that all of the samples have tested to be in the acceptable ranges. Only two sets of such samples have been tested for Ca and Mg due to the reason that the study involved only two point of use water purifiers viz. only resin based and resin cum RO-UV based and they were sufficient enough to estimate the performance of the two types of purifiers. However, it can be seen that the drinking water Sample 2 tested very low in Ca and Mg content when compared to the tap water Sample 1 which again proves that the RO purifier has removed some of the valuable minerals from the feed water (Ca, Mg and even Fe) which eventually led to the decrease in the dissolved solids content along with the decrease of pH too. The reason again being that Ca and Mg may have been in their respective carbonate forms initially showing comparatively higher pH value (Sample 1) when compared to the RO purifier derived drinking water Sample 2. Also, it can be noted that the drinking water Sample 8 contained bit higher Ca amount when compared to Sample 7, the reason can be attributed to the loosing ion-exchanging efficiency of the resin-based purifier used.

COD Content

The chemical oxygen demand (COD) is a measure of water and wastewater quality (Ahmad and EL-Dessouky). The COD test is often used to monitor water treatment plant efficiency. COD is expressed in mg/L or ppm, which indicates the mass of oxygen consumed per liter of solution. The COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products. All of the samples have been tested to have COD levels within range and the Resin cum RO purifier has proved to have performed better compared to the only Resin based purifier in decreasing the COD levels of the tap water though it was not that required as the feed water was already in its acceptable range.

Conclusion

From the present study it can be concluded that tough the underground water quality in terms of the turbidity and pH is bad, yet the IRP is effective to raise/lower it to safer levels and supply to the campus reservoirs. Most of the water samples studied met the BIS standards except for few samples owing to some reasons but not confined to water purifier issue, faulty storage reservoir (both overhead tanks and water coolers) or faulty supply pipeline. The TDS and EC have been tested to be in range. The pH can be made healthier by increasing the pH using some suitable alkaline cartridge. The turbidity for most drinking water samples were in range though the tap water samples were above the permissible limit for drinking. The metallic contents like Fe, Ca and Mg were also in permissible ranges except for the tap water sample of Zoology which needed attention. The purifier present in Human Physiology/Central Instrumentation Facility building also needs attention as the test results obtained suggests faulty purifier operation. The COD levels for all the samples were also in the permitted potable and drinking water range. Further it was also observed that with the current water status, the usage of RO based purifiers are not required in the campus as it chucks out most of the valuable minerals from water which were already in their permissible ranges and plays a vital role in our body. The RO water also rejects around 70% of feed water and gives only 30% recovery thereby wasting a lot of water during its process. Instead, an UF based purifier with just an UV chamber and alkaline cartridge is sufficient enough to take care of the point of use-based water purification method in addition to the resin-based purifiers as a pre-support for the UF-UV-alkaline cartridge purifiers which will serve as the best and economic option to provide healthy drinking water in the campus. The UF based membranes are known to not decrease the TDS of water but can very effectively remove the water Turbidity as well as some amount of microbial contamination. The UV lamp will act as the downstream microbial contamination removal after the UF process. The alkaline cartridge will fill up essential nutrients which will make the water alkaline. An effective prefilter along with an activated carbon filter is however preferred in the point of use water purification setup especially before UF-UV-alkaline cartridge purifier to take care of the excess sediments (high turbid feed water) which might get supplied due to sudden pipe leakage or faulty/open overhead water reservoirs/tanks suggesting the need for regular cleaning of the overhead tanks as well as investigation of any pipe leakages etc. The excess chlorine as well as volatile organic contents etc. if so present in the waste water is not desired and can even damage the UF membranes can be removed by the activated carbon filter. All these steps will help in ensuring a healthy water quality in Tripura University Campus.

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