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Economical and Reliable Method of Water Purification

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Abstract: In this work, several commonly used methods of water purification are discussed first and then a new method is proposed. This new method is attractive considering its simplicity and world-wide applicability. It involves boiling water under pressure which raises the temperature of this boiling water. The background of this method arises from the pasteurization process but its applicability from economy required under current high energy costs. Several experimental results are also discussed.

Key words: Ultra-violet and RO methods, water boiling method, water boiling under pressure method, high heat of water evaporation, hydrogen bonding.

Introduction

Drinking water or potable water is the water safe enough to be consumed by humans. There are drinking water quality standards which are followed world-wide such as those given in Canadian Drinking Water Guidelines; WHO (1996-2004); De Zuane (1997).

In many parts of the world, there are many people who do not get safe drinking water from their municipality because they live outside the municipal areas or in villages. In recent years, there have been mass migrations of people living in rural areas to urban areas where the entire infra-structure has collapsed and in many areas the water is supplied without any treatment.

Even those who are being supplied water, they may need to re-examine their situation based on their health condition if they have cholesterol or heart problem when their supply has chlorine which is very common in municipal supplies. Chlorine may be harmful to their health (Health Canada).

Commonly Used Methods of Water Purification

Most commonly used methods of water purification are (Canadian Drinking Water Guidelines; De Zuane, 1997); WHO, 1996-2004); Health Canada; Water Treatment; How Do Reverse Osmosis Filter Systems Work & What Do They Do):

1. Chlorination is commonly used and is cheap, but extremely toxic. It can be a carcinogen, and may sometimes be a possible cause affecting cholesterol level in the body and heart disease.

2. In ion exchange, sodium ion is exchanged for calcium or magnesium ions, using glauconite (greensand), precipitated synthetic organic resins, or gel zeolite. This way water is softened. Here, minerals, metals, chemicals or odours are not affected, and the water is salty to drink.

3. Water purification with ultraviolet (UV) light is one of the most efficient sanitary methods for eliminating viruses and bacteria in drinking water. The purification includes deactivation of all pathogenic water-borne bacteria and viruses, and also cryptosporidium cysts.

The drawback is that it requires constant monitoring of water quality with time.

4. Reverse osmosis (RO) is a purification technology that uses a semi-permeable membrane. In this method, an applied pressure is used to overcome osmotic pressure. This process can remove many types of molecules and ions from solutions. Here, the solute (the impurities) is retained on the pressurized side of

the membrane and the pure solvent (potable water) is allowed to pass to the other side.

In Reverse Osmosis water is passed under pressure through a semi permeable membrane made of cellulose acetate, aromatic polyamides, cellulose acetobutyrates or other materials. This treatment removes approximately 90 percent of dissolved solids and 98 percent of organic impurities, insoluble matter and microbiological organisms. Reverse osmosis removes only about 10 percent of ionic impurities and/or dissolved gases (Reverse Osmosis Does Not Remove Fluorides).

Another drawback with this method is that more water is rejected than passed as of acceptable quality that too is open to question.

Major problem with most of the methods above is that they require electricity supply which is very scarce when needed by large number of people living in under-developed countries.

5. Boiling water at 1 atmospheric pressure for 5 to 20 minutes and it is used very commonly. In this method also, one can get rid of bacteria, pathogens and viruses. Here, the boiling has to be vigorous i.e. throughout the volume of water. Bacteria or virus can remain if it is not done properly.

The drawback with this method is its applicability when larger volume of drinking water is needed as the energy costs these days are very high. Secondly, if the water is very polluted, severe boiling may be necessary.

Considering all these factors the objective of this work is to come up with a method which is (a) reliable, (b) ensures quality without many pre-requisites such as electricity, (c) economical, and (d) does not require instrumentation for water quality monitoring.

In this proposed new method, water is boiled in a pressure cooker/boiler. The pressure cooker is quite inexpensive. The boiling is done until the first whistle comes out of the pressure cooker. After that the cooker can be cooled at a chosen rate depending upon the insulation used during the cooling.

Boiling water in a pressure cooker or by boiling under higher pressure in a boiler and slow cooling after reaching the boiling point is a safer method and is more energy efficient than the 4th method. This method is a specific contribution of this work.

The boiler technology is very well developed since the industrial revolution and water in large quantity can be produced very easily as is done in power plants for generating electricity or for producing steam in home and building heating.

Theoretical Discussions

For this new method one needs to understand properties of water (Water purification; Holman, 2002). At atmospheric pressure (0 bar gauge), water boils at 100°C, and 419 kJ of energy are required to heat 1 kg of water from 0°C to its boiling temperature of 100°C (refer to Figure 1). It is from these figures that the value for the specific heat capacity of water (c_p) of 4.19 kJ/kg °C is derived for most calculations between 0°C and 100°C.

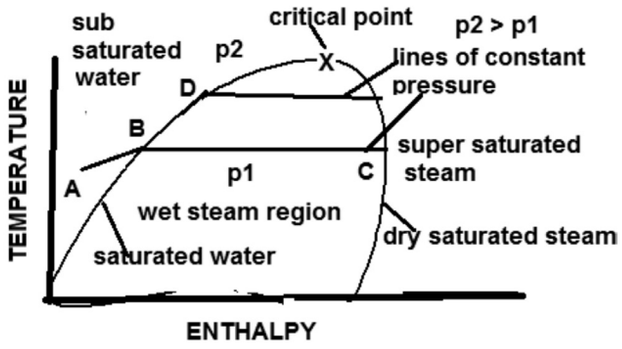

Figure 1: Temperature enthalpy diagram.

When we heat water at constant pressure as in a pressure cooker, the temperature increases from point A to B and the water approaches its boiling condition at B. If the pressure remains constant, adding more heat does not cause the temperature to rise but causes the water to form saturated steam. The temperature and pressure of the boiling water and saturated steam within the same system is the same, but the heat energy per unit mass (enthalpy) is much greater in the saturated steam.

At atmospheric pressure the saturation temperature is 100°C. However, if the pressure is increased, this will allow the addition of more heat and an increase in temperature will result without a change of phase. As the water in pressure cooker is boiled, steam starts generating at 100°C but supplying more heat results in increase in pressure and corresponding increase in temperature results as per Figure 2.

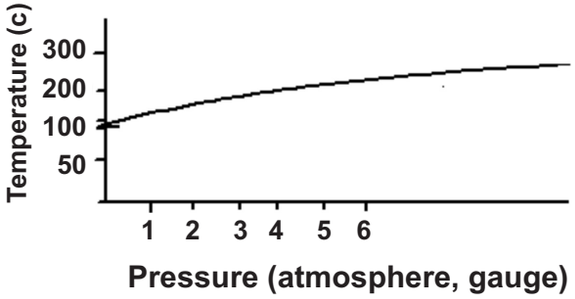

Figure 2: Variation of steam saturation curve.

Therefore, increasing the pressure effectively increases both the enthalpy of water, and the saturation temperature. The relationship between the saturation temperature and the pressure is known as the steam saturation curve (see Figure 2).

If the steam is restrained from leaving the boiler, and the heat input rate is maintained, the energy flowing into the boiler will be greater than the energy flowing out. This excess energy raises the pressure, in turn allowing the saturation temperature to rise, as the temperature of saturated steam correlates to its pressure.

Enthalpy of evaporation or latent heat is the amount of heat required to change the state of water at its boiling temperature, into steam. It involves no change in the temperature of the steam/water mixture, and all the energy is used to change the state from liquid (water) to vapour (saturated steam).

In the process suggested here, we stop when steam just starts coming out (1 atmosphere gauge) so that the temperature has reached 121 degrees C. The weight in the pressure cooker causes this increase in pressure.
Killing of bacteria and virus is dependent upon temperature, pressure and time. By insulating the cooker/boiler and allowing it to cool, the cooling rate is decreased without incurring any cost of fuel consumption.

Water has a very high specific heat capacity (4.187 kJ/kgK) – the second highest among all the heteroatomic species (after ammonia), as well as high heat of vapourization (40.65 kJ/mol or 2257 kJ/kg at the normal boiling point), both of which are a result of the extensive hydrogen bonding between its molecules.

In the ordinary boiling method, we continuously supply heat where steam is continuously formed and much of it leaves; otherwise pressure will increase. Here we supply heat based on heat of vapourization whereas in this new method – there is no heat of vapourization involved once the pressure is developed. Secondly, the temperature which is needed to kill bacteria etc. is maintained for lot longer time without supplying energy due to slow cooling. Thirdly, the system is sealed while cooling without air getting into water.

In the pasteurization process French chemist and microbiologist Louis found out experimentally that it is sufficient to heat a young wine to only about 50–60 °C (122–140 °F) for a brief time to kill the microbes, and that the wine could be nevertheless properly aged without sacrificing the final quality.

If we combine the information about (a) specific heat, (b) heat of vapourization and (c) sufficiency of the process at 60 °C, it would be quite safe if we reach the temperature of 121 °C (the boiling point of water) at 1 atmosphere gauge in the pressure cooker (the boiling point increases with the increase in pressure) and cool slowly thereby remaining above 60 °C for longer time without consuming the energy of vapourization which is quite high for water. By remaining at higher temperature the viruses get eliminated also. This principle of saving energy and time can be tested through experimentation.

The fact to be noted is that the water is heated in the pressure cooker only till the first whistle blows which ensures reaching of 121 °C. After the first whistle the heat is turned off. Whatever energy that has gone into turning water into steam is recovered when the steam condenses. The process of slow cooling can be done in still air or by insulating the pressure cooker; thereby loss of heat occurs at a slow rate where no cost is involved.

Experimentation and Results

To check the theory developed above, experiments were carried out in India on two different sources of water – (a) municipal supplied water at Shrikrishnapuri at Patna, and (b) water from river Ganga at Patna which is highly polluted. Figures 3 and 4 show the location in the river Ganga where a boat was used to collect the samples from the mid-stream of the river which is relatively less polluted than on the banks of the river due to sewage discharged from the city.

The samples, both types – from the city supply and those obtained from the river Ganga – were divided into two categories: (1) untreated, and (2) to be heated in the pressure cooker as described above. These resulting samples were analyzed in the water testing laboratory run by the Bihar State government at Chhajjubagh, Patna.

Figure 3: Boat used to collect samples from Ganga river at Patna.

Figure 4: Samples being collected from the mid-stream of the river.

There was no filtering done as the objective here was to control the water-borne diseases in accordance with the accepted standards – whether the treatment was sufficient to produce potable water.

The results of the testing are shown as Tables 1 to 6 where Tables 1 and 2 show the results of the city supply (chemical and biological analysis) and Tables 3 and 4 show the results of pressure cooker treated water. Table 5 shows results of untreated Ganga water. Here, both the chemical and biological test results are on one page. Similarly, Table 6 shows the results of pressure cooker treated Ganga water.

Tables 1 and 3 show the chemical analysis results. They show that the water quality was fine and that heating in pressure cooker (Table 3) improves the quality of results. Table 2 shows that the water as supplied by the municipality is not suitable for drinking as its coliform content was 12 which exceeded the maximum value of 10. Table 4 shows that the coliform problem goes away (coliform is absent) with treatment in the pressure cooker.

Table 5 shows the results of both chemical and biological analyses of untreated Ganga water. It shows that the Ganga water without any treatment meets the specifications as far as the chemical analysis is concerned – a surprising fact because the river flows through industrialized areas like Kanpur, Allahabad and Varanasi in Uttar Pradesh as well as Patna in Bihar. One would expect that the water will be chemically polluted but it is not. However, the biological result shows that coliform level is 16.1 far exceeding the maximum limit of 10. So, it is not fit for drinking.

Table 6 shows the results after treatment in the pressure cooker. The result in Table 6 shows that the water is fit for drinking as far as chemical analysis is concerned. Next, coming to the biological analysis, the index has reduced below 10 – is 2.6 which is far below its original value of 16.1. Thus, it is fit for drinking again. It would be better if the time in the pressure cooker is increased further but it is acceptable as is.

This method in pressure cooker is the only practical method in situations like floods, earthquakes, refugee camps etc. where people affected are large in number and no electricity supply is there. Boiling water is good but requires thorough boiling which is hard to ensure; hence it is not reliable and requires more energy or fuel than in the pressure cooker where the whistle serves as a feed-back even to a layman.

In all of these methods, water is filtered first. These filters can be purchased separately.

Conclusions

In this work, several methods of water purification were briefly discussed initially. It involved their shortcomings. Thermal properties of water-steam were discussed. It became clear that in the presently used method large amount of thermal energy is wasted or lost due to steam leaving the container. Also, the maximum temperature used is at 100 °C and it is difficult to ensure thorough boiling takes place when one produces potable water.

In the proposed method, water is heated in a pressure cooker to 121 °C. These cookers are inexpensive, widely available and simple to use. The process is stopped when the first whistle blows; thereby recovering the heat when the steam condenses. In order to prolong the system at a temperature range above the pasteurization temperature (60 °C), maximum possible insulated surfaces of the cooker are recommended.

The whistle serves as a feed-back mechanism which indicates that the system is ready to be cooled.

Table 1: Chemical analysis of municipal supplied water at Patna

STATE LEVEL WATER TESTING LABORATORY(SLWTL), PHED, GOVT. OF BIHAR, CHHAJJUBAGH, PATNA-800001
(Technical Consultancy by-Scientific Research Laboratory)

TEST CERTIFICATE

Report No:-PHE/Patna-DWfeb/D/Pat/13	
Name of the Organisation/ Person:-Mr. Anand Mohan saran	Date of Reporting:- 18/02/2013
Ref.Memo No:NM	Sample Received on:-13/02/2013
Location: -NM	Source of Sample:- Untreated water-01
Date of Sampling :-13/02/2013	
Sample Collected By :-sample not collected by us	

PHYSICO-CHEMICAL TEST REPORT

Sl.No.	Parameters	Desirable Limit*	Permissible Limit* in absence of alternate source	Method of Testing Parameters	Result
1	Colour, Hazen unit, Max	5.0	25.0	3025(part4)	5.0
2	Odour	Unobjectionable	Unobjectionable	3025(part5)	Odourless
3	PH Value	6.5-8.5	No relaxation	3025(part 10):1984	7.2
4	Turbidity,NTU,Max	5.0	10.0	3025(part II):1985	1.9
5	Total Dissolved Solid,mg/l,Max.	500.0	2000.0	3025(part 16):1984	280.0
6	Total Hardness(asCaCO3), mg/l,Max	300.0	600.0	3025(part 21):1983	263.0
7	Calcium(as Ca),mg/l,Max	75.0	200.0	3025(part 40):1991	63.0
8	Magnessium(as Mg), mg/l,Max	30.0	100.0	IS 3025:1964	29.0
9	Chloride(as Cl),mg/l, Max.	250.0	1000.0	3025(part 32):1988	48.0
10	Alkalinity(as CaCO3),mg/l,Max.	200.0	600.0	13 of3025:1964	187.0
11	Iron(as Fe),mg/l,Max.	0.3	1.0	32 of3025:1964	0.049
12	Nitrate(as NO3),mg/l,Max.	45.0	No relaxation	3025(part 34):1988	1.90
13	Sulphate(as SO4),mg/l,Max.	200.0	400.0	3025(part 24):1986	4.67
14	Fluoride(as F),mg/l,Max.	1.0	1.5	23 of3025:1964	0.28
15	Arsenic(as As),mg/l,Max.	0.01	No relaxation	3025(part 37):1988	BDL

Note:-(1) * Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993)
(2)BDL means Below Detection Limit
(3) All the testing parameters methods are taken by APHA 20th Edition

Note: **The water is fit for drinking purposes.**

Lab Incharge, SLWTL,PHED, Govt.of Bihar, Chhajjubagh, Patna-800001

Prepared by: Scientific Research Laboratory

Table 2: Biological analysis of municipal supplied water at Patna

STATE LEVEL WATER TESTING LABORATORY(SLWTL),
PHED, GOVT. OF BIHAR,
CHHAJJUBAGH, PATNA-800001
(Technical Consultancy by-Scientific Research Laboratory)

TEST CERTIFICATE

Report No:-PHE/Patna-DWfeb/D/patna/13	
Name of the Organisation/ Person:- Mr. Anand Mohan Saran	**Date of Reporting:- 18/02/2013**
Ref.Memo No:NM	**Sample Received on:- 13/02/2013**
Location: -NM	**Source of Sample:-Untreated Water-01**
Date of Sampling :-13/02/2013	
Sample Collected By :-sample not collected by Us	

BACTERIOLOGICAL TEST REPORT

Sl.No.	Parameters	Permissible Limit	Method of Testing Parameters	Result
1	Coliform Organisms,MPN/100ml	**	M-Test-Tube Technique	>12.0
2	Fecal Coliform Organisms,MPN/100ml	Absent	M-Test-Tube Technique	NIL
3	E.Coli, MPN/100ml	Absent	M-Test-Tube Technique	NIL

**(a) Throughout any year, 95% of the samples should not contain coliform organisms in 100ml
(b) No sample should contain more than 10 coliform ognanismd per 100ml
(c) Coliform organisms should not be detected in 100ml of any two consecutive samples

copy to: Mr. Anand Mohan Saran

Note: **The sample contains high coliform organisms. Hence it is not fit for drinking purposes. The water shall be disinfected by suitable treatment.**

Lab Incharge,
SLWTL, PHED,
Govt. of Bihar,
Chhajjubagh,
Patna-800001

Prepared by: Scientific Research Laboratory

Table 3: Chemical analysis of municipal supplied water at Patna after pressure cooker heating

STATE LEVEL WATER TESTING LABORATORY(SLWTL),
PHED, GOVT. OF BIHAR,
CHHAJJUBAGH, PATNA-800001
(Technical Consultancy by-Scientific Research Laboratory)

TEST CERTIFICATE

Report No:-PHE/Patna-DWfeb/D/Pat/13	
Name of the Organisation/ Person:-Mr. Anand Mohan saran	**Date of Reporting:- 18/02/2013**
Ref.Memo No:NM	**Sample Received on:-13/02/2013**
Location: -NM	**Source of Sample:- Treated water-02**
Date of Sampling :-13/02/2013	
Sample Collected By :-sample not collected by us	

PHYSICO-CHEMICAL TEST REPORT

Sl.No.	Parameters	Desirable Limit*	Permissible Limit* in absence of alternate source	Method of Testing Parameters	Result
1	Colour, Hazen unit, Max	5.0	25.0	3025(part4)	5.0
2	Odour	Unobjectionable	Unobjectionable	3025(part5)	Odourless
3	PH Value	6.5-8.5	No relaxation	3025(part 10):1984	7.1
4	Turbidity,NTU,Max	5.0	10.0	3025(part II):1985	1.9
5	Total Dissolved Solid,mg/l,Max.	500.0	2000.0	3025(part 16):1984	140.0
6	Total Hardness(asCaCO3), mg/l,Max	300.0	600.0	3025(part 21):1983	245.0
7	Calcium(as Ca),mg/l,Max	75.0	200.0	3025(part 40):1991	61.0
8	Magnessium(as Mg), mg/l,Max	30.0	100.0	IS 3025:1964	26.0
9	Chloride(as Cl),mg/l, Max.	250.0	1000.0	3025(part 32):1988	41.0
10	Alkalinity(as CaCO3),mg/l,Max.	200.0	600.0	13 of3025:1964	181.0
11	Iron(as Fe),mg/l,Max.	0.3	1.0	32 of3025:1964	0.044
12	Nitrate(as NO3),mg/l,Max.	45.0	No relaxation	3025(part 34):1988	1.70
13	Sulphate(as SO4),mg/l,Max.	200.0	400.0	3025(part 24):1986	4.11
14	Fluoride(as F),mg/l,Max.	1.0	1.5	23 of3025:1964	0.22
15	Arsenic(as As),mg/l,Max.	0.01	No relaxation	3025(part 37):1988	BDL

Note:-(1) * Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993)
(2)BDL means Below Detection Limit
(3) All the testing parameters methods are taken by APHA 20th Edition

Note: **The water is fit for drinking purposes.**

Lab Incharge, SLWTL,PHED, Govt.of Bihar, Chhajjubagh, Patna-800001

Prepared by: Scientific Research Laboratory

Table 4: Biological analysis of municipal supplied water at Patna after heated in pressure cooker

STATE LEVEL WATER TESTING LABORATORY(SLWTL),
PHED, GOVT. OF BIHAR,
CHHAJJUBAGH, PATNA-800001
(Technical Consultancy by-Scientific Research Laboratory)

TEST CERTIFICATE

Report No:-PHE/Patna-DWfeb/D/patna/13	
Name of the Organisation/ Person:- Mr. Anand Mohan Saran	**Date of Reporting:- 18/02/2013**
Ref.Memo No:NM	**Sample Received on:-13/02/2013**
Location: -NM	**Source of Sample:-Treated Water-03**
Date of Sampling :-13/02/2013	
Sample Collected By :-sample not collected by Us	

BACTERIOLOGICAL TEST REPORT

Sl.No.	Parameters	Permissible Limit	Method of Testing Parameters	Result
1	Coliform Organisms,MPN/100ml	**	M-Test-Tube Technique	NIL
2	Fecal Coliform Organisms,MPN/100ml	Absent	M-Test-Tube Technique	NIL
3	E.Coli, MPN/100ml	Absent	M-Test-Tube Technique	NIL

**(a) Throughout any year, 95% of the samples should not contain coliform organisms in 100ml
(b) No sample should contain more than 10 coliform ognanismd per 100ml
(c) Coliform organisms should not be detected in 100ml of any two consecutive samples

copy to: Mr. Anand Mohan Saran

Note: **This water sample is fit for drinking purposes.**

Lab Incharge, SLWTL,PHED, Govt.of Bihar, Chhajjubagh, Patna-800001

Prepared by: Scientific Research Laboratory

Table 5: Results of untreated Ganga water – Chemical and Biological

STATE LEVEL WATER TESTING LABORATORY (SLWTL)

PHED, GOVT. OF BIHAR

CHHAJJUBAGH, PATNA-800001

Technical Consultancy by - Scientific Research Laboratory

TEST CERTIFICATE

Report No: Pat/12-13	**Date of Reporting:** 01.03.2013
Name of the Organisation/Person: Mr. Anand Mohan Saran	**Sample Received on:** NA
Ref.Memo No: Sample no-04	**Date of Sampling:** NA
Location: NA	**Source of Sample:** NA
Sample Collected By: Not Collected by SLWTL	

PHYSICO-CHEMICAL TEST REPORT

Sl. No.	Parameters	Desirable Limit*	Permissible Limit* in absence of alternate source	Method of Testing Parameters	Results
1	pH Value	6.5-8.5	No relaxation	pH meter	7.25
2	Turbidity, NTU, Max	5.0	10.0	Nephalometric	4.00
3	Conductivity, µmho/cm	-	-	Conductivity meter	310.00
4	Total Dissolved Solid, mg/l, Max.	500.0	2000.0	Conductivity meter	200.00
5	Total Hardness(as $CaCO_3$), mg/l, Max	300.0	600.0	EDTA method	170.00
6	Calcium(as Ca), mg/l, Max	75.0	200.0	EDTA method	24.04
7	Magnesium(as Mg), mg/l, Max	30.0	100.0	EDTA method	17.63
8	Chloride(as Cl), mg/l, Max.	250.0	1000.0	Titration	49.63
9	Alkalinity(as $CaCO_3$), mg/l, Max.	200.0	600.0	Titration	190.00
10	Iron(as Fe), mg/l, Max.	0.3	1.0	Phenonthroline	0.64
11	Nitrate(as NO_3), mg/l, Max.	45.0	No relaxation	UV-method	0.32
12	Sulphate(as SO_4), mg/l, Max.	200.0	400.0	Turbidimetric	27.42
13	Fluoride(as F), mg/l, Max.	1.0	1.5	SPANDS	0.44
14	Arsenic(as As), mg/l, Max.	0.01	0.05	AAS	BDL

Note: *(1) Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993)
(2) BDL means Below Detection Limit
(3) All the testing parameters methods are taken by APHA 20th Edition

BACTERIOLOGICAL TEST REPORT

Sl. No.	Parameters	Permissible Limit	Method of Testing Parameters	Results
1	Coliform Organisms, MPN/100ml	**	M-Test-Tube Technique	16.1

Note: **(a) Throughout any year, 95% of the samples should not contain coliform organisms in 100ml
(b) No sample should contain more than 10 coliform organisms per 100ml
(c) Coliform organisms should not be detected in 100ml of any two consecutive samples

Copy forwarded for kind information to:
(i) Consultant Water Quality Cell , PHED, Govt. of Bihar
(ii) Director, Water Quality Cell, PHED, Govt. of Bihar
(iii) Engineer-in-Chief cum Special.Secretary, PHED, Govt. of Bihar

Lab Incharge,
SLWTL,PHED,
Govt.of Bihar,
Chhajjubagh,
Patna-800001

Prepared by: Scientific Research Laboratory

Table 6: Results of treated Ganga water – Chemical and Biological

STATE LEVEL WATER TESTING LABORATORY (SLWTL)

PHED, GOVT. OF BIHAR

CHHAJJUBAGH, PATNA-800001

Technical Consultancy by - Scientific Research Laboratory

TEST CERTIFICATE

Report No: Pat/12-13	**Date of Reporting:** 01.03.2013
Name of the Organisation/Person: Mr. Anand Mohan Saran	**Sample Received on:** NA
Ref.Memo No: Sample No-06	**Date of Sampling:** NA
Location: NA	**Source of Sample:** NA
Sample Collected By: Not Collected by SLWTL	

PHYSICO-CHEMICAL TEST REPORT

Sl. No.	Parameters	Desirable Limit*	Permissible Limit* in absence of alternate source	Method of Testing Parameters	Results
1	pH Value	6.5-8.5	No relaxation	pH meter	7.39
2	Turbidity, NTU, Max	5.0	10.0	Nephalometric	1.00
3	Conductivity, µmho/cm	-	-	Conductivity meter	200.00
4	Total Dissolved Solid, mg/l, Max.	500.0	2000.0	Conductivity meter	130.00
5	Total Hardness(as $CaCO_3$), mg/l, Max	300.0	600.0	EDTA method	70.00
6	Calcium(as Ca), mg/l, Max	75.0	200.0	EDTA method	24.04
7	Magnesium(as Mg), mg/l, Max	30.0	100.0	EDTA method	1.60
8	Chloride(as Cl), mg/l, Max.	250.0	1000.0	Titration	120.53
9	Alkalinity(as $CaCO_3$), mg/l, Max.	200.0	600.0	Titration	160.00
10	Iron(as Fe), mg/l, Max.	0.3	1.0	Phenonthroline	0.29
11	Nitrate(as NO_3), mg/l, Max.	45.0	No relaxation	UV-method	0.18
12	Sulphate(as SO_4), mg/l, Max.	200.0	400.0	Turbidimetric	34.22
13	Fluoride(as F), mg/l, Max.	1.0	1.5	SPANDS	0.21
14	Arsenic(as As), mg/l, Max.	0.01	0.05	AAS	BDL

Note: *(1) Drinking Water Specification First Revision -IS:10500:1991,Edition 2.2(2003-09)(Reaffirmed1993)
(2) BDL means Below Detection Limit
(3) All the testing parameters methods are taken by APHA 20th Edition

BACTERIOLOGICAL TEST REPORT

Sl. No.	Parameters	Permissible Limit	Method of Testing Parameters	Results
1	Coliform Organisms, MPN/100ml	**	M-Test-Tube Technique	2.6

Note: **(a) Throughout any year, 95% of the samples should not contain coliform organisms in 100ml
(b) No sample should contain more than 10 coliform organisms per 100ml
(c) Coliform organisms should not be detected in 100ml of any two consecutive samples

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(ii) Director, Water Quality Cell, PHED, Govt. of Bihar
(iii) Engineer-in-Chief cum Special Secretary, PHED, Govt. of Bihar

Lab Incharge,
SLWTL,PHED,
Govt.of Bihar,
Chhajjubagh,
Patna-800001

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Health Canada. Drinking Water Health Problems. http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/chlor-eng.php

Holman, J.P. (2002). Heat Transfer. McGraw Hill, 9th Edition.

How Do Reverse Osmosis Filter Systems Work & What Do They Do? http://espwaterproducts.com/about-reverse-osmosis.htm

Reverse Osmosis Does Not Remove Fluorides. http://orbisvitae.com/ubbthreads/ubbthreads.php?ubb=showflat&Number=62526

Steam. http://en.wikipedia.org/wiki/Steam

Water purification. https://en.wikipedia.org/wiki/Water_purification

Water Treatment: Ultraviolet Disinfection of Private Water Supplies for Household or Agricultural Uses. http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1241475412160

World Health Organization (1996–2004). Guidelines for Drinking Water Quality, Vols. 1–3. Geneva, Switzerland.

Calendar of Events

3rd Journal Conference on Environmental Science and Development (JCESD 2014 3rd)
4th and 5th July 2014
Nottingham, United Kingdom
Website: http://www.ijesd.org/jcesd/3rd/
Contact person: JCESD
Organized by: CBEES

5th International Conference on Environmental Engineering and Applications (ICEEA 2014)
4th and 5th July 2014
Nottingham, United Kingdom
Website: http://www.iceea.org/
Contact person: Mr. Issac Lee
Organized by: CBEES

2014 Stormwater NSW/ACT Conference
7th to 16th July 2014
Canberra, Australian Capital Territory, Australia
Website: http://www.gemsevents.com.au/stormwaternsw
Contact person: Peta Freeman
Organized by: Stormwater NSW

2nd Annual International Conference on Water, 14-17 July 2014, Athens, Greece
14th to 17th July 2014
Athens, Greece
Website: http://www.atiner.gr/water.htm
Contact person: Gregory Papanikos

3rd Annual Water Management in Mining Summit
28th to 30th July 2014
Denver, Colorado, United States of America
Website: http://bit.ly/1t2Hgvv
Contact person: Water Management in Mining Team
Organized by: IQPC

International Conference on Environment and Natural Resources (ICENR 2014)
29th and 30th July 2014
Hong Kong, China
Website: http://www.icenr.net/
Contact person: Ms. Mickie Gong
Organized by: CBEES

Small Water Wastewater Systems National Conference
13th and 14th August 2014
Newcastle, NSW, Australia
Website: http://www.awa.asn.au/swws2014/
Contact person: AWA Events
Organized by: Australian Water Association

International Conference on Water, Informatics, Sustainability and Environment
26th to 28th August 2014
Gatineau - Ottawa, Canada
Website: http://www.iwiseconference.com
Contact person: W. A. Eldin

Water Loss Asia 2014
3rd and 4th September 2014
Kuala Lumpur, Malaysia
Website: http://www.waterlossasia.com/
Contact person: Agnes Tan
Organized by: PROTEMP Exhibitions Sdn Bhd

2014 4th International Conference on Energy and Environmental Science (ICEES 2014)
4th and 5th September 2014
Kuala Lumpur, Malaysia
Website: http://www.icees.org/
Contact person: Ms. Rebecca Yang
Organized by: IACSIT

ENVIRO'14
17th to 19th September 2014
Adelaide, South Australia, Australia
Website: http://www.enviroconvention.com.au
Contact person: ENVIRO'14 Secretariat
Organized by: Australian Water Association & Waste Management Association Australia