Research Article

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A STUDY ON DRINKING WATER QUALITY ANALYSIS IN RURAL PLACES OF WEST BENGAL

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Abstract: Drinking water is the basic requirement for life and a determinant of standard of living. However, besides government efforts, supply and demand side factors of both surface and groundwater determine the level of drinking water available to people. The supply and demand factors increase with the natural and human factors like pollution. This limits drinking water supply provision and raises the delivery cost. Decline in groundwater table and availability of surface water, particularly in summer months are major problems. Poor water quality has also been observed in more number of habitations. Inadequate resource management and institutional system seems to be the major causes for the present problems. We examine the nature and magnitude of environmental problems, causes and impacts on drinking water supply. The study observes the different methods used to analyse the quality of water, also the diseases caused due to unsafe drinking water are discussed. Moreover remedial measures to promote safe drinking water are suggested.

Keywords: determinant, environmental problems, ground water, inadequate resource, remedial measures, water quality.

INTRODUCTION

Drinking water or portable water is defined as water of sufficiently high quality that can be consumed or used without risk of immediate or long term harm.[1,3]

An adequate water resource for future generations is not only a regional issue but also a global concern. Our country's fresh water wealth is under threat due to variety of natural and human influences. Arsenic, fluoride and heavy metals occur as minor constituents of ground water in all categories of hydro-geological settings in India. The high concentration of these minor constituents including iron and nitrate is of major concern.[2]

Drinking water in safe quality is a basic requirement for life and a determinant of standard of living. Poor or no access to safe water supply can result in many diseases including diarrhoea, flurosis, cholera, hepatitis, trachoma, etc. These ailments potentially constrain human resource development and productivity, especially of the poor. [1,8]

The shortage of water in the West Bengal is slowly affecting the lives of people as well as the environment around them. Some of the major issues that need urgent attention are:

- As a result of excessive extraction of ground water to meet agriculture, industrial and domestic demands, drinking water is not available during the critical summer months in many parts of West Bengal.[5]
- About 40 per cent of the rural and urban population do not have access to regular safe drinking water and many more are threatened. Most of them depend on unsafe water sources to meet their daily needs. Moreover, water shortages in cities and villages have led to large volumes of water being collected and transported over great distances by tankers and pipelines.
- Chemical contaminants namely fluoride, arsenic and selenium pose a very serious health hazard. It is estimated that about 3.5 million people in West Bengal are at a risk due to excess fluoride. [1,2,4,8]

Of all the planet's renewable resources, water has a unique place. It is essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de-pollute and expensive to transport.

If we look at the present scenario of the rural places in West Bengal, the availability and quality are questionable. Water quality problems in the rural places are caused by pollution and over-exploitation. The rapid pace of industrialization and greater emphasis on agricultural growth combined with financial and technological constraints have led to generation of large quantities of waste and pollution. The problem is aggravated due to the non-uniform distribution of rainfall.

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The main aim of this project is determine the quality of water obtained from rural places and to find out the various problems caused due to excess of certain elements and also to suggest effective remedial measure to improve the quality of water. [1]

Name of the water Sample:

1. Pond Water (Daspur, West Midnapur)
2. Tube well water (Joynagar, south 24 parganas)
3. Tube well water (Uluberia checkpost)
4. Tap water (College canteen- CIT, Uluberia)
5. Tap water (Chemistry Department Laboratory)

MATERIALS AND METHODS

The quality of water is not determined by just a simple test, on the contrary there are a number of tests that help us determine the quality of water and they are broadly classified into the

- Physical quality
- Chemical quality
- Microbiological quality

Physical parameters

The following physical parameters were studied to analyze the physical quality of water are

- pH
- Dissolved oxygen (DO)
- Total dissolved solids (TDS)
- Turbidity

pH

The logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per liter; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral and greater than 7 is more basic and less than 7 is more acidic).[1,10]

Working procedure for pH meter

If you want high precision of measurements it is better to let the pH meter to warm up for some time (like 30 minutes) to ensure it will not drift later. Before every single pH measurement, or before any series of uses, you must calibrate pH electrode.

After calibration you are ready to measure pH. Rinse electrode and submerge it in the tested solution. Read the result and write it down in your lab notebook. Rinse the electrode.

Table 1: analysis of pH for different drinking water samples

Test Sample no.	Measure Values of pH
1	6.98
2	6.81
3	6.88
4	7.19
5	7.11

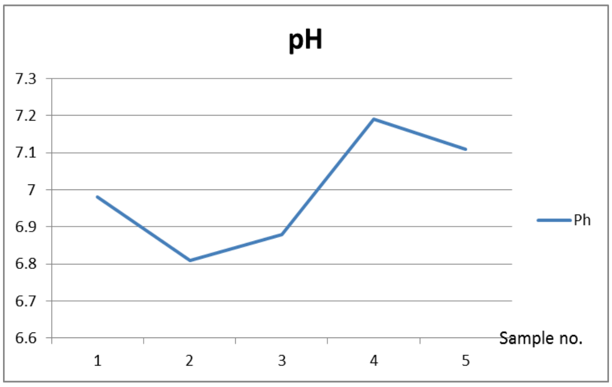

Figure 1: Variation of pH for different drinking water sample

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality,

Working Procedure for Turbidimetry

In analytical chemistry, methods for determining the amount of cloudiness, or turbidity, in a solution based upon measurement of the effect of this turbidity upon the transmission and scattering of light. Turbidity in a liquid is caused by the presence of finely divided suspended particles. If a beam of light is passed through a turbid sample, its intensity is reduced by scattering, and the quantity of light scattered is dependent upon the concentration and size distribution of the particles. In nephelometry the intensity of the scattered light is measured, while, in turbidimetry, the intensity of light transmitted through the solution.[5]

Methodologies

Warm the pH meter for 15 minutes, calibrate the pH meter by 100ml buffer solution (Ph=4,standard solution). Then again by 100ml pH =7 buffer solution. After every calibration the electrode must be rinsed by distilled water. Then testing takes place of the respective samples.

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Apparatus required

Turbidity Meter, Sample Cells, Standard flasks, Funnel, Wash Bottle and Tissue Papers.

Chemicals required

Hexamethylenetetramine, Hydrazine sulphate, Distilled water.

Standard 400 NTU Solution

- Mix 5ml of hydrazine sulphate solution and 5ml of hexamethylenetetramine solution in a 100ml standard measuring flask.
- Make up the volume to 100ml using turbidity free distilled water.
- The standard 400NTU solution is ready.

Testing of Water Sample

- To the sample cells, add sample water up to the horizontal mark, wipe gently with soft tissue and place it in the turbidity meter.
- Check for the reading in the turbidity meter.
- The turbidity of the given water sample is 8.4 NTU.

Table 2: analysis of turbidity for different drinking water samples

Test Sample No.	Temperature of Sample in °C	Turbidity (NTU)
1		12
2		8
3	29	8
4		10
5		9

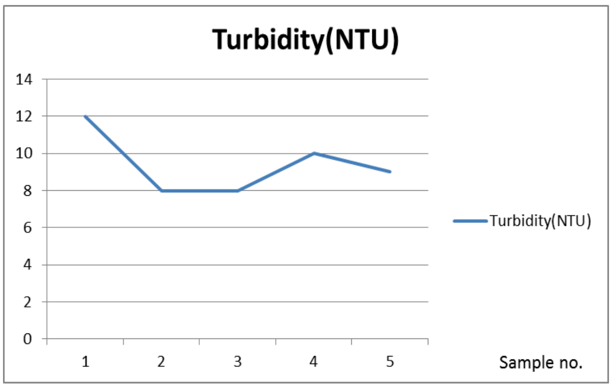

Figure 2: Variation of Turbidity for different drinking water sample

Double Beam UV Spectrometer

Any molecule has n, π, σ or a combination of these electrons. These bonding (π and σ) and non bonding (n) electrons absorb the characteristic radiation and undergo transition from ground state to excited state. By the characteristics absorbtion peaks, the nature of the electrons present and hence the molecular structure can be elucidated.

Electronic transitions and excitations process

It was stated earlier that σ, n and π electrons are present in molecule and can be excited from the ground state by the absorption of UV radiation. The various transition or

→ n π* → π π* → n σ * ,σ → σ *

The different energy states associated with such transition can be given by the diagram

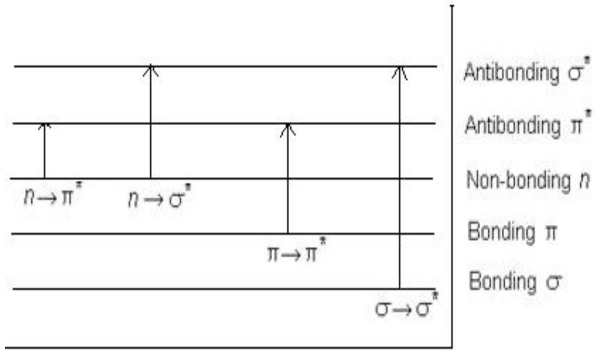

Figure 3: shows as the energy required for excitation for different transition are n → π*< π π*< n → σ*< σ σ*. Of these transitions n → π* required the lowest energy and σ σ* required the highest energy.

Procedure

As per IP the wave length (λ max) of the standard water is 195 nm. So we measure the UV range from 192nm to 220nm in double beam spectrometer, take the standard water sample in two different sample holder of the instrument (UVS 1700-shimadze) then the reference absorbance is taken as zero after zero calibration and then we need to take the serial sample in following sequence at 200nm.

Table 3: Analysis of absorbance in terms of optical density for different drinking water sample

Test sample no	OD Density	
1	0.129	
2	2.830	Wavelength λ (nm)
3	0.972	217
4	0.367	
5	0.047	

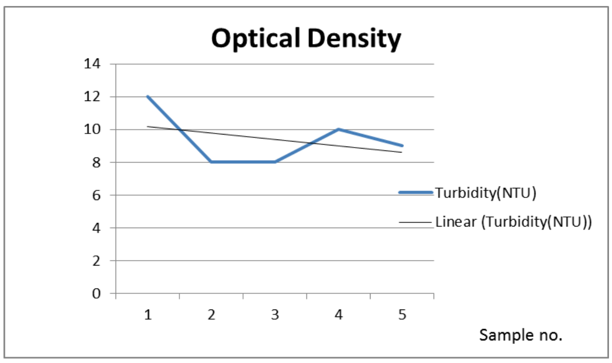

Figure 3: Variation of Optical Density for different drinking water sample

Ultraviolet Radiation

- When UV radiation penetrates the cell wall of an organism, it damages genetic material, and prevents the cell from reproducing.
- Nowadays emerging technology made UV radiation to find a place in both household and large-scale drinking water disinfection.
- How UV light is generated?
- Ultraviolet light is most typically generated from a low pressure or a medium pressure lamp generating UV light.
- The basic principle is that the genetic material in the presence of UV light gets denatures, If there are two thymine groups adjacent to each other in the DNA molecule then they dimerise which causes the denaturing.[4,6,10]

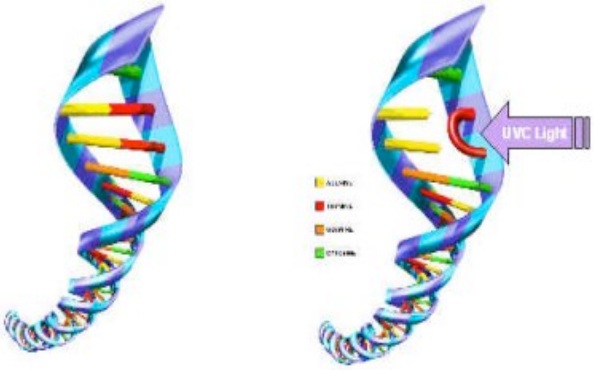

Fig.5: This diagram represents the dimerization of the thymine base

Chemical Oxygen Demand (COD)

It is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals.

Principle

The organic matter gets oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 (50% of the total volume) to produce CO_2 and H_2O at elevated temperature. The excess $K_2Cr_2O_7$ remaining after oxidation of organic matter is titrated with standard Fe $(NH_4)_2$ $(SO_4)_2$ .6 H_2O. The dichromate consumed gives the O2 required for oxidation of organic matter.

Interferences:

Fatty acids, straight chain aliphatic compound, chlorides, nitrates and iron are the main interfering radicals.

1mg/l Cl^- exert 0.23mg/l COD while 1mg/l NO_2 exerts 1.1mg/l COD. These interferences can be eliminated as described below:

Addition of $HgSO_4$ eliminates Cl interference by precipitating Cl as $HgCl_2$. Addition of silver sulfate as catalyst to concentrated H_2SO_4 stimulates oxidation of straight chain aliphatic and aromatic compound. Sulphuric acid in the amount of 10mg/mg NO_2 may be added to $K_2Cr_2O_7$ solution to avoid interference caused by NO_2.

Chemical Oxygen Demand (COD)

Chemical oxygen demand test determines the oxygen required for the complete oxidation of biologically degradable and non-biodegradable organic matter. Infact it determines the pollution strength of the material. The organic matter in reduced state such as Cl, CN and NO_2 also gets oxidized. Since COD amounts for all organic matter irrespective of biodegradable or non-biodegradable, oxidized completely in COD test.[2,4,8]

Apparatus

a. COD digester
b. Reflux tubes
c. Pipette
d. Analytical balance

Reagents

a. Standard potassium dichromate (0.25N)
b. Sulphuric acid reagent
c. Standard ferrous ammonium sulfate (0.25N)
d. Ferroin indicator
e. Mercuric sulfate
f. Silver sulfate
g. Distilled water

Procedure

a) Add 50mL of sample or an aliquot diluted to 50mL with distilled water in a 500mL-refluxing flask. Add 1g $HgSO_4$, few glass beads, and 5mL sulphuric acid reagent, mix, cool. Add 25mL of 0.0417M $K_2Cr_2O_7$ solution, mix. Connect the flask to the condenser and turn on cooling water, add additional 70mL of sulphuric acid reagent through open end of condenser, with swirling and mixing.

b) Reflux for 2hours; cool, wash down condenser with distilled water to double the volume of contents, cool.

c) Add 2 drops of Ferroin indicator, titrate with FAS the remaining potassium dichromate, until a color change from bluish green to reddish brown. Also reflux and titrate distilled water blank with reagents.

d) Use standard 0.00417M $K_2Cr_2O_7$ and 0.025M FAS, when analyzing very low COD samples.

e) Evaluate the technique and reagents by conducting the test on potassium hydrogen phthalate solution.

f) Do not add grease at the Leibig jacket to prevent jamming, use water instead.

Table 4: analysis of cod for different drinking water samples

Test Sample No.	COD (mg/lt)	WBSPCB (West Bengal State Pollution Control Board) LIMIT (mg/lt)
1	365	
2	310	
3	295	250
4	215	
5	185	

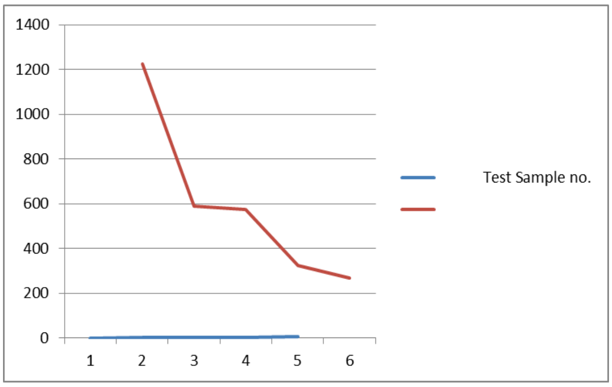

Figure 4: Variation of COD for different drinking water sample

Calculations

$$COD\ (mg/ml) = \frac{(A-B)*N*8*1000}{V}$$

Where

A= Titre value of sample (ml)
B = Titre value of Blank (ml)
N= Normality of FAS
V= Volume of sample (ml)

Biochemical Oxygen Demand (BOD)

The amount of oxygen required to degrade the organic matter under aerobic conditions at constant temperature is called BOD.

Principle

The method consists of filling a specially manufactured airtight "BOD bottle" with sample to overflowing and incubating it at specified temperature conventionally at 20°C for 5days or 27°C at 3 days and the BOD is computed from the difference between initial and final DO (dissolved oxygen).

Many biological treatment plant effluents contain sufficient number of nitrifying organisms to cause nitrification in BOD tests. Because oxidation of nitrogenous compound can occur in such sample, inhibition of nitrification is recommended for sample of secondary effluents for samples seeded with secondary effluent and sample of polluted water.

Environmental significance

Since BOD is directly proportional to the organic matter concentration, value of BOD is taken as the strength of pollution. In environmental engineering this parameter is very important for designing treatment plant and assenting efficiency of the plant.

Apparatus

a. BOD bottles, 300 mL, narrow mouth, flared lip, with tapered and pointed ground glass stoppers.
b. Air incubator or water bath thermostatically controlled at 27 ± 1°C. Light entry must be prevented in order to avoid photosynthetic oxygen production
c. Accessories: plastic tube, screw-pin and a 5-10 L water container.

Reagents

a. Phosphate buffer solution. Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4.7H_2O$ and 1.7 g NH_4Cl in 1L distilled water.
b. Magnesium sulphate solution. Dissolve 22.5 g $MgSO_4.7H_2O$ in 1L distilled water.
c. Calcium chloride solution. Dissolve 27.5 g $CaCl_2$ in 1L distilled water.
d. Ferric chloride solution. Dissolve 0.25 g $FeCl_3.6H_2O$ in 1L distilled water.
e. Acid and alkali solution. 1N NaOH and 1N H_2SO_4. Use for neutralising samples.
f. Glucose-glutamic acid solution (prepare fresh). Dissolve 150 mg dry reagent grade glucose and 150 mg dry reagent grade glutamic acid in 1L distilled water g. Sample dilution water. Add 1 mL each of phosphate buffer, $MgSO_4$, $CaCl_2$ and $FeCl_3$ solutions per litre distilled water.

Procedure

a. Prepare required amount of dilution water at the rate of 1000 to 1200 mL per sample per dilution. Bring the diluted water temperature to 27°C. Saturate with air by shaking in a partially filled bottle, by bubbling with organic free filtered air or by storing in cotton-plugged bottles for a day.

b. Some samples do not contain sufficient microbial population (for example, some industrial wastes, high temperature wastes, or wastes with extreme pH values). For such wastes, the dilution water is seeded using effluent from a biological treatment system processing the waste. Where this is not available, use supernatant from domestic wastewater after settling for at least 1 h but not more than 36 h. Seed from a surface water body receiving the waste may also be suitable. Add enough seed volume such that the DO uptake of the seeded dilution water is between 0.6 and 1.0 mg/L. For domestic wastewater seed, usually 4 to 6 mL seed / L of dilution water is required. Surface water samples usually do not require seeding. Laboratory Manual.

c. Dilution of sample. Dilutions must result in a sample with a residual DO (after 3 days of incubation) of at least 1 mg/L and a DO uptake of at least 2 mgl/L. Make several dilutions using the Table and experience with the particular sample source. Polluted surface waters may have 5 to 25 mg/L BOD Using percent mixture By direct pipetting into 300mL bottles Range of BOD % mixture Range of BOD mL Sample.

Using percent mixture		By direct pipetting into 300mL bottles	
Range of BOD	% mixture	Range of BOD	mL Sample
1,000 - 3,500	0.2	1,200 - 4,200	0.5
400 - 1,400	0.5	600 - 2,100	1.0
200 - 700	1.0	300 - 1,050	2.0
100 - 350	2.0	120 - 420	5.0
40 - 140	5.0	60 - 210	10.0
20 - 70	10.0	30 - 105	20.0
10 - 35	20.0	12 - 42	50.0
4 - 14	50.0	6 - 21	100.0
0 - 7	100.0	0 - 7	300.0

Table Dilutions for varying BOD values

a. For preparing dilution in graduated cylinders, siphon dilution water, seeded if necessary, into a 1 to 2 L capacity cylinder. Siphoning should always be done slowly without bubbling, use a screw-pin on the tube to regulate the flow. Keep the tip of the tube just below the water surface as it rises. Fill cylinder half full, add desired quantity of sample and dilute to appropriate level, mix with plunger type mixing rod. Siphon mixed diluted sample in three BOD bottles, stopper without entraining any air. Determine initial DO on one bottle and incubate the other two at 27°C. Determine final DO in duplicate after 3days.
b. For direct pipetting, siphon the desired sample volume to individual bottles and fill with enough dilution water. Complete the test as in the earlier case.
c. Dilution water blank. Find the DO consumption of unseeded dilution water by determining initial and final DO as in c above. It should not be more than 0.2 mg/L
d. Seed control. Determine the DO uptake by seeding material according to the procedure in above.[7]

Table 5: analysis of bod for different drinking water samples

Test Sample No.	BOD (mg/lt)	WBSPCB (West Bengal State Pollution Control Board) LIMIT (mg/lt)
1	1225	
2	590	
3	575	700-800
4	323	
5	268	

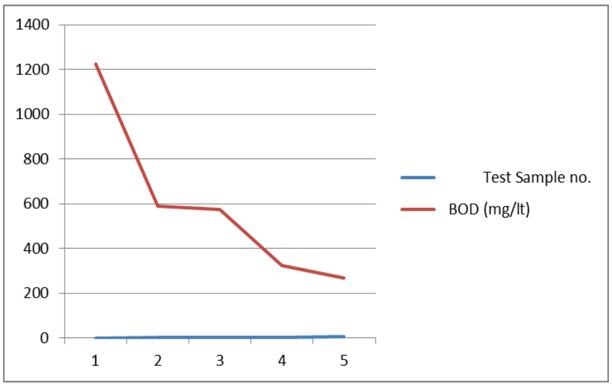

Figure 5: Variation of BOD for different drinking water sample

Calculation

When dilution water is not seeded:

$$BOD_{3,27},\ mg.l^{-1} = \frac{D_0 - D_T}{P}$$

Where:

Do = DO of diluted sample initially, mg/L
DT = DO of diluted sample after 3 day incubation at 27°C, mg/L
P = decimal volumetric fraction of sample used
Bo = DO of seed control initially, mg/L
BT = DO of seed control after incubation, mg/L
f = ratio of %seed in diluted sample to %seed in seed control

CONCLUSION

Water is necessary for most life on Earth. Humans can survive for several weeks without food, but for only a few days without water. There is a grave necessity to adopt water purification methods in order to improve the standards of living. The implementation of the simpler methods is more practical for the rural places. The government also needs to take an initiative and immediate action is required to provide cleaner and purer water.

The quality of water in various rural places of West Bengal were studied, the methods used to analyze the quality of water were addressed. Moreover the diseases caused due to unsafe drinking water were brought to light; in addition to these remedial measures were suggested.

It was found that C.I.T canteen water as well as C.I.T chemistry laboratory water had pH over acceptable limit making it unfit for drinking and West Midnapur pond water was found to have pH within the acceptable pH limit.

The West Midnapur pond water was found to have the maximum turbidity and minimum optical density while the tube well water samples collected from South 24 parganas and Uluberia highlighted minimum turbidity results amd maximum optical density.

The COD for pond water and tube well water were determined to be out of the permissible limit unlike which the C.I.T. canteen and laboratory water showed positive results falling inside the allowable limit.

The BOD test revealed an interesting result as all collected water samples except the one from the pond in West Midnapur fell within the allowable range.

Future Studies

There are wide ranges of options for future studies in the field of drinking water quality analysis.

- We can expand our research and studies to the urban areas of West Bengal and conduct a comparative study.
- We can also study and check for purity of different bottled water.
- We can study and investigate the amount of harmful metals in the wastewater generated by different industries.
- We can design the process of purification of drinking water by reducing impurities.ie; Total Suspended Solid (TSS) and other physical qualities.

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