
RESEARCH PROPOSAL

The *Barakar River* is the main tributary of the *Damodar River* in eastern India. Originating near *Padma* in *Hazaribagh district of Jharkhand* it flows for 225 kilometers (140 mi) across the northern part of the *Chota Nagpur Plateau*, mostly in a west to east direction, before joining the *Damodar* near *Dishergarh* in *Asansol, Bardhaman, West Bengal*.

We were allotted the *Barakar River* at *Asansol* to be our area of survey. We went there on 22nd of November 2017 from the school, along with one of our teachers.

Weather – Sunny

Temperature – 23°C

Time of collection of water sample – 10:35 a.m.

Wind – Light, 14 km/hr

CURRENT STATE OF WATER BODY

CULTURAL SIGNIFICANCE

- Festivals like *Chhath* are celebrated on the banks of the river.
- Idol immersions are done during every festival.
- Beside the *Barakar River*, a temple is situated, which is about 40 years old.
- There is a crematorium just beside the river.

SCIENTIFIC SIGNIFICANCE

- *The Maithon Dam* - This dam was specially designed for flood control and generates 60,000 kW of electric power. There is an underground power station, the first of its kind in the whole of South East Asia. The dam is constructed on the *Barakar River*. The reservoir is spread over 65 square kilometers. *Maithon Hydel Power Station (MHPS)* is located on the river *Barakar* about 12.9 km above its confluence with the *Damodar* near the border of *Dhanbad & Burdwan* districts of the states of *Jharkhand & West Bengal* respectively. The unique feature is that, it is located underground in the left bank of the river and is the first of its kind in India. The power station has a total generating capacity of 60 MW with 3 units of 20 MW each. *MHPS* is located at almost 100 feet below the water level.

- The river is heavily used for household purposes. Like,
 - ✓ **Bathing** – Humans as well as cattle.
 - ✓ **Drinking** – Local people say that the water is safe for drinking & they often consume it without any purification.
 - ✓ **Water Supply** – Water of this river is supplied by the local municipality after purification and all the necessary cleaning processes which is accessed by the local people via taps.
 - ✓ **Washing** – Local people wash their clothes over here daily.
 - ✓ **Fishing** – Fishes of local varieties are found here in large quantities and fished by the local people. Anyone can fish over here & no special membership is required for fishing.
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CURRENT WATER QUALITY

The West Bengal Pollution Control Board regularly tests the water quality. As per their data on [BARAKAR AT ASANSOL \(WATER INTAKE POINT\), WEST BENGAL](#) -

- It is **alkaline** in nature as its **pH** is seen to be in the range of **7.0-8.0**.
- It seems to have **very low level of contamination** (that decreases the clarity of the water), and this is proved as the *turbidity* of the water at Barakar river is always seen to lie between the range **0-10 NTU**, which is quite low.
- The **water hardness is quite low** as it lies in the range of **80-145 mg/l**. The water hardness is a measure of certifying water as favorable for drinking. As the water hardness is quite low it *may be used for drinking purposes after some treatment*. But *due to the seasonal variation of the water quality (higher concentration of iron in the summer season)*, as per the Journal of Environmental Research and Development, *using the water for drinking may be harmful too*.
- The **nitrate** level of the water at Barakar is also in the favorable level. The *maximum level of nitrate in water is 10 mg/l* whereas it **always ranges between 0-2 mg/l** mentioned as per West Bengal Pollution Control Board and Journal of Environmental Research and Development.
- Next is the **fluoride** content of the water. The [U.S. Department of Health and Human Services](#) (HHS) has revealed that the *fluoride content in drinking water can be 0.7 mg/l (maximum level)*, whereas the water at Barakar river is tested to be in the range **0.3-0.8 mg/l** (tested by [Journal of Environmental Research and Development](#) and [West Bengal Pollution Control Board](#)).
- The **chloride** level water can be **250 mg/l (maximum)**, whereas the average chloride level of Barakar river water is **24.464 mg/l** which is not harmful.
- As per Chemistry for Environmental Engineering and Science, if the **BOD (Biological Oxygen Demand)** of a water body is **1-2 mg/l**, then it can be claimed the water body is clean, i.e., contains less organic wastes, if it is **3-5 mg/l** then the water is moderately clean and if it is between **6-9 mg/l** then it means that the water is somewhat polluted and in case the BOD is greater than **100 mg/l** then the water is polluted. The BOD of the water at Barakar has ranges from **1 mg/l to 3 mg/l** but the BOD level also reaches to **4.0 or 5.0** like, in 2016 it was **5.7 mg/l** in the month of September.

- Next is the **Dissolved Oxygen** level. This component varies with temperature (directly). The Dissolved Oxygen level of Barakar river water is found to be **13.9 mg/l in summer season** and **8.9 mg/l in winter season**.
- As per [U.S. Environmental Protection Agency](#), if the **TDS (Total Dissolved Solid)** level is less than 500 mg/l then the water quality is excellent, and as per the test conducted by the West Bengal Pollution Control Board and Journal of Environmental Research and Development, the **TDS level of the Barakar river remains in the range of 100-300 mg/l**.
- The **Total Suspended Solids (TSS)** is a cause of increased turbidity. As the turbidity level is low so the total suspended solids in the river water is also low which **ranges from 1 to 100 mg/l**.

Thus, from the above data it is clear that the water quality of the Barakar River is quite good for household purposes and it can also be inferred that the coal mines near the river, which affects the water quality of Damodar, as per the Journal of Environmental Research and Development, does not affect the water quality of the Barakar river which is a tributary of the Damodar river itself.

WATER USES (Detailed in the Scientific Significance)

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| <ul style="list-style-type: none"> ✓ Water Reservoir at Maithon Dam. ✓ Washing clothes and vessels. ✓ Bathing. ✓ Fishing ✓ Crematory works. | <ul style="list-style-type: none"> ✓ Temple works and use of the water during festivals. ✓ Navigational activities at Maithon Dam. ✓ Idol immersions. ✓ The sand on the river bed is used for constructional purposes. |
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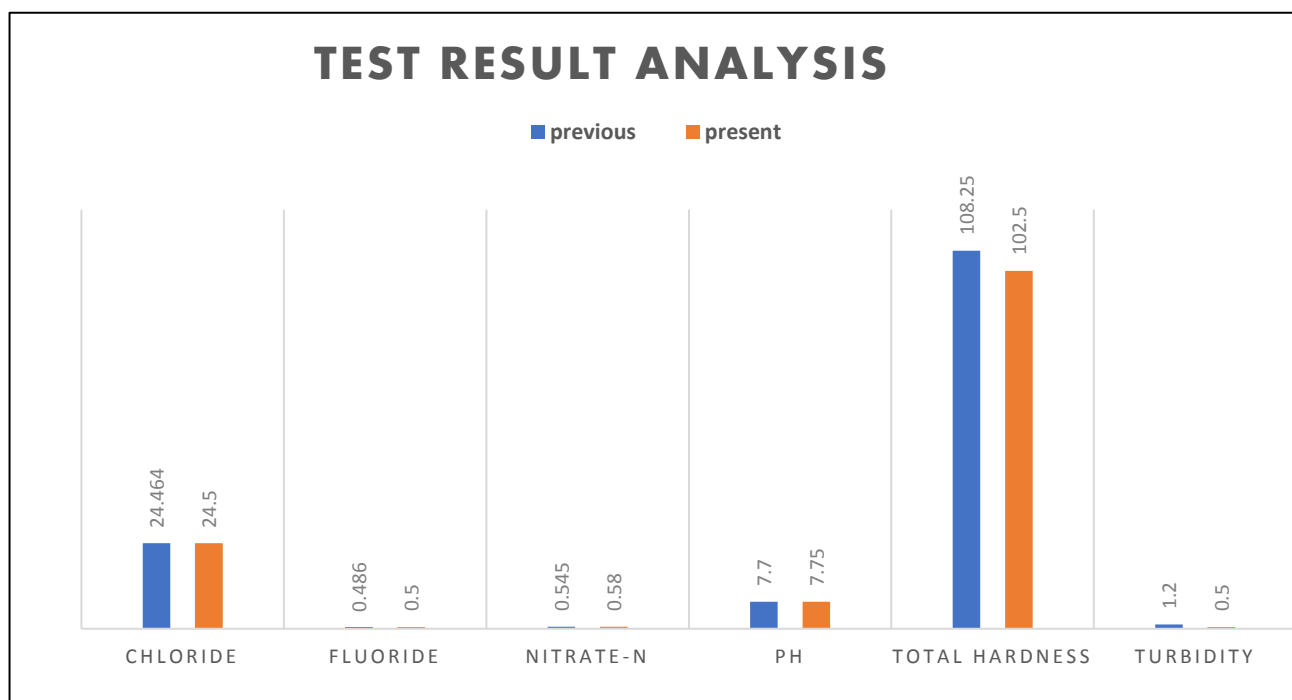
PILOT DATA

- The Barakar river is originating near Padma in Hazaribagh district of Jharkhand it flows for 225 kilometers (140 mi) across the northern part of the Chota Nagpur Plateau, mostly in a west to east direction, before joining the Damodar near Dishergarh in Asansol, Bardhaman, West Bengal
- The Barakar river water is hard and alkaline due to use of soaps and detergents in water in large quantities for household purposes.
- The water consists of adequate amount of mineral content due to the presence of coal mines nearby.
- The water is less contaminated as industrial waste deposition is absent and the household wastes are also not allowed to mix up with the river water.
- The river has high utility at the Maithon dam for power generation.
- The water is consumable as the local people use it for drinking and hasn't caused any serious diseases.

RELEVANCE OF OUR RESEARCH WITH PREVIOUS RESEARCH

DAV MODEL SCHOOL, DURGAPUR conducted a research on the water quality of the *Barakar River*. Thus, after a series of tests, the results drawn, are shown below:

Date of sample	-	22.11.2017
Date of experimentation	-	23.11.2017
pH	-	7.75
Turbidity (NTU)	-	0-10
Total hardness (mg/l)	-	45-100
Chloride (mg/l)	-	< 25
Iron (mg/l)	-	0.2
Residual chlorine (mg/l)	-	0.00
Nitrate	-	0-10 (tends to be 0, data provided as per as the scale provided)
Fluoride (mg/l)	-	0.75



It is clearly visible from the graph that the tests conducted by DAV MODEL SCHOOL, DURGAPUR is quite similar with the test results conducted by *West Bengal Pollution Control Board (WBPCB)*. In the graph the bars

colored blue is the test result obtained by WBPCB and the orange colored bars depict the test results of DAV MODEL SCHOOL, DURGAPUR.

RESEARCH QUESTIONS

On basis of the research conducted by DAV MODEL SCHOOL, DURGAPUR, a series of research questions (both descriptive and relational type) were plotted and preferred answers were also drawn:

- **What is the water level during summer season and rainy season?**
 - ✓ *The water level of Barakar river remains 10-15 feet at the center of the river and during the rainy season the water level rises to about 30-45 feet at the center, this change of level is also a cause of flood in the local areas. Thus, the river is claimed as “savior as well as destroyer”.*
- **For what purposes the river water is used?**
 - ✓ *The water is highly used for household purposes like bathing, washing clothes and vessels, fishing and also for drinking purposes. The water of the river is sent to a tank nearby and then, after some treatment, it is supplied to the localities by the municipality.*
- **Is there any special usage of the river water?**
 - ✓ *The river water is used for hydel power production in the Maithon Dam, which produces about 60 MW of energy. The dam also acts as a reservoir and has several utilities like navigation and supply of water to industries.*
- **Has the water ever resulted to any kind of diseases after using it for drinking or bathing?**
 - ✓ *The local people claim that the water hasn't resulted to any kind of diseases. But, during the rainy season the water quality varies. Thus, sometimes leads to certain skin diseases. The river water then, is rarely drunk directly and most of the locals primarily filter it and then use it for drinking purposes. Sometimes, the traditional method of filtration is also used, i.e., by digging a pit beside the river where the soil layer partially filters out the water. They proclaimed that, may be some minute diseases have occurred but no such major diseases have ever occurred after usage of the water of the river.*
- **Is the water of Barakar River used or affected by any industry?**
 - ✓ *The water of the Barakar River is not used or affected by any industry. But the water quality is affected by the pollution caused in the Damodar River due to the presence of coal mines surrounding it.*

Then the local people were also asked if the water is clean or is it cleaned after any festive usage like *Chhath*, and they replied that the water is clean and is also cleaned after such festive usage. This cleanliness is proved by a system of separated sewage flow beside the river which, according to them, doesn't mix with the river.

They were also asked certain relational research questions

- **Is the water seen to lose its clarity in any season?**
 - ✓ *During the rainy season, the water is seen to lose its clarity accompanied by a change in color, i.e., the water turns yellowish. Otherwise, in rest of the months, the river water is clear.*
 - **Have the people ever felt their skin to become oily or dry while using the water?**
 - ✓ *The local people didn't observe any specific changes. (but by observation, it was visible that most of the people using the water had dry skin)*
 - **Is any kind of wastes dumped into the water directly?**
 - ✓ *No such wastes are dumped into the river directly but sometimes it may be done at the crematorium.*
 - **Does the water color change in any season?**
 - ✓ *Yes, it does in the rainy season, it changes to somewhat yellow color. But remains the same in all other seasons.*
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SIGNIFICANCE OF THE RESEARCH AND ITS HELP TO OTHER RESEARCHES

The research conducted by [DAV MODEL SCHOOL, DURGAPUR](#) is a complete analysis of the water quality of the Barakar river water.

- ✓ It helps to explore the reasons of variation in the water quality of a water body. It also allows us to know the various reasons for the change of various components of water quality with various aspects.
- ✓ It lets the people and the students know about various aspects of water quality like turbidity.
- ✓ It lets us spread awareness about how people, who are a component of the hydrological cycle, can upgrade instead of degrading the quality of the resources, they are exploiting.
- ✓ It lets people know about the current water quality of the resource they are using.
- ✓ The research is a source of potential which can be used for larger projects like [EXPLORING WATER QUALITY IN INDIA AND KENTUCKY](#).
- ✓ The research helps the students to learn the process of interaction which is a major part of any kind of research.

- ✓ This research is a mix of basic and applied research type, i.e., it helps to construct new knowledge and to show how the findings can be applied or summarized into some type of methodology.

The research conducted by DAV MODEL SCHOOL, DURGAPUR is just like other researches conducted by the West Bengal Pollution Control Board and Journal of Environmental Research and Development. But it also adds up some new data like *the test for determining if the water preferable for drinking purposes and the residual chlorine test.*

- ✓ The presence of **residual chlorine** in water indicates that: 1) a sufficient amount of chlorine was added initially to the water to inactivate the bacteria and some viruses that cause diarrheal disease; and, 2) the water is protected from recontamination during storage. But the Barakar river water is found to have 0.00 mg/l residual chlorine which means the water may get contaminated after storing it for few days and also indicates that if any bacteria are present in the water it shall not be killed if no treatment is done.
- ✓ The **Bacteriological Field testing** for **determining if the water is suitable for drinking** or not. The H₂S strip test allows the microbial quality of drinking water to be assessed without any use of expensive laboratory equipment. The method is inexpensive, simple and visual where a water sample changes color. If the initial yellow color changes to black after 48 hours then it is not suitable for drinking or else it is.
 - But after testing the water sample twice with the testing kit, it was found that water retains the yellow shade for the first four days and then turns black, which proves the consequences of the absence of residual chlorine.

These tests help us to determine whether the water is portable or not, which is one of the important aspect of a water body.

HYPOTHESES

Based on the research conducted on the Barakar River water we can say:

- ✓ *The river water is highly used for household purposes like bathing, washing clothes and vessels which involves usage of soaps and detergents. Moreover, the water is also used by washer men. These **soaps and detergents increase the basicity of the water. Thus, the water can be predicted to be alkaline in nature.** This also can increase the hardness of water to some extent due to the presence of Ca^{++} and Mg^{++} ions.*
- ✓ *Since, the water is not used for dumping wastes or discharging effluents from industries thus the **contamination level is estimated to be low** and thus the **turbidity** (which is a measurement of contamination of water bodies due to the presence of algae, dissolved and suspended particles, and other micro-organisms) **shall also be low.***
- ✓ *Since, there is low contamination thus the **BOD, i.e., Biological Oxygen Demand of the water is also expected to be low,** which increases with increase in presence of organic matter in the water.*
- ✓ *Less usage of water by industries for discharging effluents indicates **lower presence of total suspended solids.** But it may increase during the rainy season due to the drainage water flowing by the river getting mixed with the main course of the river.*
- ✓ *As the people consider the water as a source of drinking, so it can be estimated that **the water consists of favorable amount of fluoride, chloride, nitrate, etc.***
- ✓ *People also proclaim that fishing is very common in the river thus it **can be expected that the river has favorable amount of dissolved oxygen and favorable conditions for the aquatic world.***
- ✓ *As no such industrial effluents are discharged and no such organic matters are dumped into the river water thus it is also **expected that the total dissolved solids are low** (which increases by the presence of particles like salts, ionized or micro-granular (colloidal sol), etc.)*
- ✓ *As the river has not caused any such major diseases thus it is **expected that the bacterial growth in the river water is quite low,** except during the rainy season when the drainage water gets mixed with the main course of the river.*
- ✓ ***The water hardness is predicted to be a bit high** due to the enormous use of the water for intensive cleansing purposes such as bathing, washing clothes, etc.*

All these predictions are expected to be the results of the tests that are conducted by the authorized departments (West Bengal Pollution Control Department and Journal) as well as by the school.

The predictions are made on the basis of the answers of the research questions mentioned above.

These are some of the predictions that can be claimed as the propositions that may be in support with the final results of the tests conducted with the help of the testing kit provided and with the results of pre-tests conducted by the West Bengal Pollution Control Board.

RESEARCH METHODS

- **Online Research Analysis-** At first, we the students of DAV Model School, Durgapur conducted an online research analysis on Barakar River. We collected all the data about the water quality of the previous years. We read between the lines of the previous years' research reports.
- **Preparation of Research Questions-** Then, we prepared the research questions on which we basically worked upon. The questions were regarding the cultural significance, non-consumptive as well as consumptive usage.
- **Collection of water –** We went to the assigned area, i.e., the Barakar River at Asansol along with a teacher and collected the water sample from the river. At first, we went to a depth of 1 ft and collected the water at a depth of 20-30 cm in a laboratory flask.
- **Interrogating the people-** Then we started interrogating the local people about various aspects of the water quality such as its cultural significance, non-consumptive as well as consumptive usage. We also enquired about the variation in the water level as well as the quality in different seasons.

Normal level (as on 22 nd November 2017)	- 10 ft.	at the center
Summer	- 3-5 ft.	at the center
Monsoon	- 45-50 ft.	at the center
- **Experimentation on the Water Quality-** We returned and on the next day, carried out our first experiment on the water with the provided kit. The kit also contained a manual including instructions of proceeding into each test. The kit contained a graduated tube, a small beaker, black screw capped bottles, plastic dropper, bacteriological vials, and other necessary equipment for each test. Prior to every single test we cleansed the testing equipment with distilled water to ensure accurate results. We followed the manual, step by step for ensuring precision and accuracy.
 - **pH-**
 - We filled the water sample up to 4ml mark in the black screw bottle.
 - We added 2 drops of reagent from Bottle No. PH1 and mix gently.

- We compared the color developed in the tube with the color chart and found out the pH value.
- **Turbidity-**
 - We placed the turbidity tube on a flat surface in a sufficiently lit area.
 - We poured the water sample using the 50ml Beaker in a gradual rate and took note of the any change in the visibility of the yellow circles at the bottom.
 - Accordingly, we drew the conclusion from it.
- **Total Hardness-**
 - We took 10ml of water sample in the 20ml graduated glass stoppered tube.
 - We added 4 drops of reagent from the Bottle H1 and mixed it properly.
 - Then we added reagent from Bottle H2 drop wise till a color change from wine red to blue was noticed.
 - We counted the number of drops required and multiplied it with factor 15 to get the results in mg/l.
- **Chloride-**
 - We took 5ml of the water sample in 20ml graduated glass stoppered tube.
 - Then we added 2 levelled plastic spoons of reagent from Bottle C1 and mixed it properly. We noticed a change of color from blue to purple.
 - We kept on mixing and while shaking, we added 2 drops of reagent from Bottle C2 till the color changed to yellow.
 - We added reagent from Bottle C3 drop wise till we observed the first color change from yellow to purple.
 - Simultaneously, we counted the number of drops required for the color change and multiplied it with factor 25 to conclude.
- **Iron-**
 - We filled the water sample up to the 10-ml mark in the black screw capped bottle.
 - We added 4 drops of reagent from Bottle FE1 and mixed it gently for 2-3 minutes.
 - Then we added 2 level spoons of reagent from Bottle FE2 and mixed it till the powder got completely dissolved.
 - After a few minutes, we compared the developed color from the top of the tube with the color chart and noted our observation.
- **Residual Chlorine-**
 - We added two drops of reagent from Bottle CL 1 to an empty black screw capped bottle.
 - We filled the bottle up to the 10ml mark with the water sample.
 - Finally, we compared the developed color immediately with the color chart from the side of the bottle and noted down our observation.
- **Nitrate-**
 - We filled the water sample up to the 10ml mark in the black screw capped bottle.
 - We added 1 level plastic spoon of reagent from Bottle N1 and 5 drops of reagent from Bottle N2
 - We replaced the plug cap and mixed it gently.
 - We let the bottle stand for 2 minutes for the complete reaction to take place

- Then we added 5 drops of reagent from Bottle N3 and mixed it gently.
- After 10-15 minutes, we compared the color change with the given color chart and noted down the corresponding concentration.
- **Fluoride-**
 - We filled the water sample up to the 4ml mark in the black screw capped bottle.
 - We added to it 1 ml of reagent from Bottle f! using the dropper and mixed it properly.
 - We then, compared the developed color with the given color chart to note the concentration.
- **Bacteriological field testing-**
 - We filled the water sample into the given vial up to the 20ml mark carefully.
 - We closed the cap and shook it for a few minutes gently.
 - We then let it stay in the same environmental condition for 48 hrs.
 - Exactly at the 48th hour, we noted down the results.

We proceeded through the further experiments in this same process for 4 more times. After these 5 tests, we drew conclusions by taking average of each test to ensure accuracy

- **Comparison of Experimental Data with Online Data-** following the prior trend –
 - **pH-** *The pH of the river water is found to be alkaline in nature during the Nov-Dec period of every other year, and the same was concluded from our own experimentation.*
 - **Turbidity-** *The turbidity of the water is found to be fluctuating between 0-10 NTU every year.*
 - **Total Hardness (for CaCO₃) -** *The total hardness of the water is found to be increasing at a gradual rate. But our experimentation gave different results on different tests.*
 - **Chloride-** *The chloride content of the water is found to be less which means favorable. In each of our five tests, the chloride content of the water was found to be below 25 mg/l.*
 - **Iron –** *The iron content of the water is quite low, which is favorable for usage. As per the online data, the iron content increases during the months of April and June, and as per our test, we found that the iron content remains in the range of 0-0.5 mg/l which is quite near to negligible and thus matches with the online data.*
 - **Residual Chlorine-** *The residual chlorine of the water is found to be negligible, i.e., the value is 0.00 mg/l. This determines that the water can't be stored quite safely. This test is an add-on to the tests conducted by the authorized departments.*
 - **Nitrate-** *The nitrate content of the water is quite low, which is a favorable composition. The nitrate composition is found to be in the range of 0-10 mg/l but the color change of the solution during the test was very light thus can be said to be nearly in the range 0-2 mg/l. This result is same as that to the test conducted by West Bengal Pollution Control Department.*
 - **Fluoride-** *The fluoride content of the water is also low, enough to make it suitable for usage. The online data provides a range of 0-1 mg/l and the same is drawn from our test (average-0.50 mg/l).*
 - **Bacteriological field test-** *This test is also an add-on to the other tests. This is the test which provides us with the proof whether the water is safe for consumption or not. From our tests, there wasn't any noticeable change in color in the 48th hour (as directed in the manual)*

but the water had turned completely black in the next 30 hours. Hence, we can say that the water is suitable for consumption but, storing it, can degrade its quality by a huge margin.

- **Reflection on social setting-** Along with the experimentation we also took up initiative in spreading the message to our peers and teachers which includes:
 - Demonstration of the project through presentation in the school.
 - Conducting podcast featuring our teachers.
 - Publishing monthly Newsletters.
 - Preparing pamphlet about the project and distributing it to our peers and teachers.

Due to the limited scope of spreading awareness in the school, we presented every work of our research on our website dav-water.weebly.com so that our message is perceived worldwide.

This part of the project was a great help for us in enhancing the quality of our project, due to a large proportion of suggestions from those who attended our awareness programs.

- We found , to increase the accuracy of the project report we should compare the data of minimum 2 years that is of 2016, 2015, and if possible 2014.
 - We also found that it would be more helpful, if we could include more tests. Thus, we conducted the residual chlorine and bacteriological field testing, but we could not extend it to more due the school limitations.
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RESULTS

From the tests conducted by the students of DAV Model School, Durgapur we can conclude that:

- **THE TEST RESULTS:**

PARAMETER	EXPERIMENT#1	EXPERIMENT#2	EXPERIMENT#3	EXPERIMENT#4	EXPERIMENT#5
Date of Sample	22.11.2017	22.11.2017	22.11.2017	22.11.2017	22.11.2017
Date of Experimentation	23.12.2017	24.12.2017	27.12.2017	28.12.2017	29.12.2017
pH	7.75	6.75	6.75	6.5	6.5
Turbidity(NTU)	0-10	0-10	0-10	0-10	0-10
Total Hardness(as CaCO ₃)(mg/l)	180	45	45	45	15
Chloride(mg/l)	<25	<25	<25	<25	<25
Iron(mg/l)	0.2	0.1	0.2	0.2	0.185
Residual Chlorine (mg/l)	0.00	0.00	0.00	0.00	0.00
Nitrate(mg/l)	0-10	0-10	0-10	0-10	0-10
Fluoride(mg/l)	0.50	0.50	0.50	0.50	0.50

- The **pH** of the water at Barakar is alkaline in nature, i.e., the pH of the water ranges from 6.0-8.0 units and the reason is high usage of the water for bathing, washing clothes and vessels, etc which increases the water alkalinity. But, from the conducted tests it is also found that the water pH drops day by day that is the water pH drops from alkaline to acidic.

- The **Turbidity** of the water is quite low which means the water is less contaminated. The turbidity of the water remains constant throughout every test. The measure of turbidity lies in the range of 0-10 NTU
- The **Total Hardness(as CaCO₃)** of the water is also quite low which indicates that lower energy is lost while using the water, but it also reduces the protective nature of water from cardio diseases. The total hardness of the water was 180 mg/l in the first test but the hardness dropped to 45 mg/l and then to 15 mg/l.
- The **Iron** content of the water hovers between 0.1-0.2 mg/l. The presence of high iron can contribute to diseases like anaemia and ward off fatigue on consumption. But our experimentation on iron gave a substantial low value, which is favourable.
- The **Chloride** content of the water is below 25 mg/l throughout the five experiments. At greater levels, chloride can complicate existing heart problems and contribute to high blood pressure when ingested in excess. But the water had very little chloride content which is again, favourable.
- The **Residual Chlorine** in the water is found to be 0. Chlorination of water destroys all animal and microbial life, leaving no trace of it afterwards, but the Barakar River water had almost no trace of residual chlorine, which is favourable for the aquatic life. But the water cannot be stored safely for longer period due to the lower presence of nitrate in the river water.
- The **Nitrate** content of the water is very low, hovering between 0 and 10 mg/l, which means the water is not dumped with chemical wastes which increases the nitrate level of water. Moreover, it also prevents the groundwater pollution due to high nitrogen level.
- The **Fluoride** content of the water is also quite low. The average value is 0.50 mg/l. It is found that the fluoride content of the water helps to prevent dental caries at drinking water concentrations of about 1 mg/L. High fluoride body burden, kidney patients have an elevated risk for developing skeletal fluorosis which is also prevented by the water of Barakar River.
- The **Bacteriological Field Test** has proved that the water is quite safe for drinking as the colour of the solution does not changes from yellow to black. This means the water can be drunk. But as it contains meagre amount of residual chlorine, the water needs to be purified and if stored for longer duration, it may prove to be fatal.

CONCLUSION

From the analysis, programs, and the tests conducted, it is clear that the water of Barakar River is of high utility and enormous potential (used for power generation), and thus, if provided with necessary maintenance, can bring glory to the many lives.

- From the tests conducted on the water of Barakar River the following conclusions were drawn:
 - The water is alkaline, i.e., the pH of the water is in the range of 7.0-7.5 (for first test), which is caused due to the use of soaps and detergents in water. Moreover, the river passes through the coal mine and thus is added upon by minerals like carbonates, bicarbonates, etc. Moreover, as the pH ranges from 6.0-8.0 from the next tests so the water's buffering power is also good and this is favorable for the aquatic life.
 - The Turbidity of water is quite low. Thus, the water can be concluded to be less contaminated also safe for usage as water with higher turbidity causes gastrointestinal diseases.
 - The *Total Hardness (as CaCO₃)* of the water is also at a *favorable range of 75-200 mg/l* which is *effective for suitable osmoregulation, i.e., maintaining precise levels of internal salts for normal heart, muscle and nerve function*. Calcium is also important in the molting process of shrimp and other crustaceans, and can affect the hardening of the newly formed shell. Also, Aquatic animals can tolerate a broad range of calcium hardness concentrations thus they are also not affected by the total hardness range.
 - The *chloride content of the water is also suitable* which is *important in ensuring proper health conditions* after usage of the water, resisting diseases like alkalosis.
 - The *Iron content is also suitable*, thus resisting deficiency anemia, chronic anemia, cough, and pre-dialysis anemia.
 - The *parameter of water which is not adequate is the residual chlorine, which needed to be 0.5 mg/l or more, but it is completely absent* in the water of the Barakar River. Thus, *it cannot ensure the proper and safe storage of the water*.
 - The *nitrate content is suitable in quantity and ensures proper health conditions* after usage of water.
 - Also, the *fluoride content of the water is as per the required amount*. It prevents tooth decay and possibly Osteoporosis.
 - Last but not the least, the *Bacteriological Field Test ended with positive results*. From the tests, we can conclude that the *water is suitable for immediate consumption*. However, *storing the water for longer durations is not recommended* due to the absence of residual chlorine which in turn, can trigger a significant growth of microbes.
- *The results support the hypotheses provided by us, i.e., almost all the answers to the research questions are matching with the inference drawn from the test results. Except the part where the hypotheses says that the water is 'totally' safe for drinking, but the water is not quite safe for drinking.*

- As per observation, the Damodar River, of which Barakar is a tributary, is highly polluted. But the pollution reduces as it moves downstream as found in the Barakar River water. Moreover, the variation of the parameters with seasonal variation also reduces. Though the pollution level has increased by a huge margin since 2014, but the water quality of Barakar hasn't been much affected. The water quality parameters such as carbonate, iron, phosphate, ammonia content is usually affected by the presence of coal mines nearby any water body. But the effect of the presence of coal mines near the Barakar River is barely noticeable in its water quality.
 - But it is expected that further research on the river water shall provide more results. It is suggested to compare the water quality closer to the junction point of the Barakar and Damodar River so that the water quality change can be minutely observed, as the pollution level reduces in Damodar River in its downstream which may also be the same for the Barakar River. Moreover, if more drinking water tests are extended, it would help in producing a more comprehensive result, as the population dependence for the drinking purpose is huge. Hence, it needs to be ensured whether the water is totally safe for drinking with primary filtration or not. It is also suggested to determine the effect of the presence of coal mines near the Barakar River in a more comprehensive way.
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DOCUMENTATION OF SOURCES

- The data sources are
 - WEST BENGAL POLLUTION CONTROL BOARD-
<http://emis.wbpcb.gov.in/waterquality/showwqprevdatachoosedist.do>
 - JOURNAL OF ENVIRONMENT RESEARCH AND DEVELOPMENT -
www.jerad.org/ppapers/dnload.php?vl=6&is=3A&st=638
 - Data source of the facts about Damodar, Barakar River, Maithon Dam, etc. is WIKIPEDIA.
 - Data about the favorable values of various parameters:
 - www.who.int
 - <https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5014a1.htm>
 - www.bfhd.wa.gov/info/nitrate-nitrite.php
 - www.freedrinkingwater.com/water-education/quality-water-ph-page2.htm
 - Data for module 1 and our other works of module 2 (awareness programs, video, newsletter etc) can be found in our website - dav-water.weebly.com
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