# STUDIES ON PHYSICO-CHEMICAL PARAMETERS OF THE TWO COAL WASHERIES EFFLUENT NEAR DAMODAR RIVER OF DISTRICT BOKARO, JHARKHAND

## ANJU KUMARI [1*] AND DR. RUPAM MALLIK [2]

[1]Department of Zoology, Binod Bihari Mahto Koyalanchal, University, Dhanbad, 826004 Jharkhand, India. Email.id: -

kumarianju.patel@gmail.com

[2]Department of Zoology, Binod Bihari Mahto Koyalanchal, University, Dhanbad, 826004 Jharkhand, India. Email.id: -

rupam.mallik@gmail.com

Corresponding Author: **Anju Kumari**

**ABSTRACT**

The present investigation was carried out to assess the Physico- Chemical properties of Damodar River water near two Coal washery named Moonidih Coal washery and Dugda Coal washery of district Bokaro, Jharkhand, India. Water samples were collected on monthly basis from November 2021 to October 2022. A total 1 to 10 parameters were analysed by selecting the most practicable methods available in the Standard Method for examination of water and also waste water as per APHA, 2005. The average value of selected water parameters of River water near Moonidih Coal washery and Dugda Coal washery, the temperature was 24.07°C. -24.60°C, Electrical conductivity (EC) 1118.67-800.6 µs/cm, Dissolved Oxygen (DO) 6.56-6.18mg/L, pH 8.1625-7.34, Total Dissolved Solids(TDS) 776.07-698.34 mg/L, Biological Oxygen Demand (BOD) 4.22-4.09 mg/L, Sulphate ($So_4^{2-}$) 54.17-56.32 mg/L, Nitrate ($No_3^-$) 8.57-7.01 mg/L, Chloride ($Cl^-$) 78.39-72.58 mg/L, Turbidity 29.56-24.43(NTU), respectively. Pearson's correlation coefficient values show high significant positive and negative relationship (p<0.05 level).

According to calculated WQI, 85.39 River water near Moonidih Coal Washery shows very poor-quality status and 62.09 River water near Dugda Coal Washery shows poor quality status as per Water Quality Index rating.

## INTRODUCTION

Water, the base of life, constitutes about 70% of the body weight in the living beings. (Singh *et al* 2013, Singh and Kamal 2014.). But there is only 1% of out of whole earth's water available in rivers, lakes, streams, reservoirs and groundwater is suitable for living being's consumption 2% locked in polar ice caps and 97% is in the ocean. It is estimated that around 7 billion people out of the projected 5.3 billion in the entire world will face water shortage problem and out of these 40% will suffer acute water crises. In India's case the future is a bit worse. Since, we have only 2. 45%of the world's landmass, supporting 16%of the world's population and our fresh water resources doesn't exceeding 4% of the global resources Apart from availability, continuous water pollution due to disposal and other wastes are going on. Damodar River, one of the most important rivers of India, flowing across the Indian states of Jharkhand and West Bengal . It flows through the industrial towns of Chandrapura, Ramgarh, Bokaro, Jharia Dhanbad, Durgapur, etc. (Sen, P K. 1991; Chandra,S. 2003; Bhattacharya, K.2011 ).This river basin is credited of first Coal Mining in India in 1815( Singh, 1992). The river is quite wide and carries the effluents of several types like coal mines, coal washeries, Coke oven plants, thermal power plants, Bokaro steel plant, cement plant, different types of potential pollutants, adversely affecting

the riverine ecosystem and thus degrading the water quality .(Ghosh *et al* , 1984 ;Dhar 1993 , Bell and Karr, 1993) Physico- chemical parameters of river water play vital role in river ecosystem and that are reported in various literatures. An Ecosystem's functional characteristics are determined by the interactions between physical, chemical and biological aspects. Ascertaining the quality is crucial before its use for various purposes such as drinking, agricultural and industrial uses, etc. Sargaonkar & Deshpande 2003, Khan *et al* 2003).

To see the inter relationship among the various parameters; some mathematical analysis would reflect significance of quality of water. (Hardgrave *et al.*,1994). The coefficient correlation method is the statistical mathematical tool used to develop to know the relationship between the Physico -Chemical parameters or others (Brown *et al*. 1970; Bhandari and Nayal, 2008.). The coefficient correlation helps in the investigation of the existence and degree of freedom of the relationship between two or more variables (Tripathi *et al.*,2014).

Water quality index (WQI) is another statistical tool and very useful and efficient method for assessing the suitability of water for different purposes, especially for drinking. It is also very useful method of communicating the information on all over quality of water (Tiwari *et al* 1985.,Yisa *et al* 2010.) to the related authority. Water Quality

Index was proposed by Brown and his co-workers. It converts a large number of data into a single value.

## MATERIALS AND METHODS

### Study area

Bokaro district is located in the Eastern part of India at $23^0$ 45'38.40" latitude and $86^0$ 3'10.66" E longitude. It is located in picture square surrounding on the Southern bank of river Damodar. The two sites were selected for Physico-Chemical analysis in which one site is (Damodar River water near Moonidih coal washery $S_1$), with latitude $23.7418^0$ N, and longitude $86.2816^0$ E and another site is (Damodar River water near Dugda Coal washery $S_2$) with latitude $23.7376^0$ N and longitude $86.1512$ E.

### Sampling and Analysis

Water samples from the two selected sampling sites were collected from November 2021 to October 2022. Samples were taken in 2 liters capacity of pre closed bottles. Collection and analysis of samples were done monthly. Samples collection was done between 8 AM to 11 AM. Temperature, pH and Electrical Conductivity were measured by Thermometer, Portable conductivity and pH meter respectively.

Other parameters like Dissolved Oxygen (DO), Total Dissolved Solid (TDS) Biological Oxygen Demand (BOD), Nitrate ($NO_3^-$), Chloride ($Cl^-$), Sulphate ($SO_4^{2-}$), Turbidity was analyzed according to the Standard Methods APHA-2005.

### Statistical Analysis

### Water Quality Index

An Instrument used to evaluate the general quality of water in a given area is the Water Quality Index (WQI). Water Quality Index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water (Tyagi et al 2013)). Water Quality Index aims at giving a single value to the water quality of a source on the basis of one or the other system which translates the list of constituents and their concentrations present in a sample into a single value.

Water Quality Index developed by Brown and his co-workers provide an expression for the overall water quality. It is a mathematical equation used to measure and evaluate the water quality and clarify that the water is suitable for drinking and other domestic purposes or not. It takes into account a multitude of water quality parameters with reference to World Health Organization (WHO) and Indian Standard B I S.

For the present work to fulfill the purpose of calculating Water Quality Index6.Indian standard BIS for drinking water I.S 10500 have been taken into consideration.

Table 1: - Showing Standards for drinking water as per mentioned BIS &WHO.

| Parameters | BIS Standards (Desirable limit) | WHO Standards (Desirable limit) |
|---|---|---|
| Temp | - | - |
| Ph | 6.5 - 8.5 | 7.0 - 8.5 |
| Dissolved Oxygen (DO) | 4 - 6 mg/L | -- |
| Total Dissolved Solids (TDS) | 500 mg/L | 500 mg/L |
| Electrical Conductivity (EC) | 300 µs/cm | 180 – 1000 µs/cm |
| Chlorides (CL-) | 250 mg/L | 250 mg/L |
| Nitrate | 45 mg/L | 50 mg/L |
| Sulphate | 250 mg/L | 250 mg/L |
| Turbidity | 5 NTU | 5 NTU |

For the calculations of WQI, three steps have been taken.

Step -1 To calculate Wn means unit weight factors for each parameter following equation was used

Wn=k/sn

Where

Wn is the unit weight for the $n^{th}$ parameters.

Sn is the Standard Value of the $n^{th}$ parameters

K is the constant proportionality k=1/1/s1+1/s2+1/s3+1/s4 1/sn

1/Σ1/sn

Step-2. To Calculate Sub index (Qn) value, the equation is given below

Qn=[ (Vn-Vi)/(Sn-Vi)]

Where

Qn is the sub index of $n^{th}$ parameter

Sn is the standard value (I S 10500) for the $n^{th}$ parameter

Vi is the ideal value for each parameter in pure water.

Vi of pH is 7 and Vi of DO is 14.6. Generally, Vi is 0 for other parameters.

Step 3-Finally, WQI is calculated as

=ΣWnQn

Overall WQI=ΣWnQn/ΣWn

Where

Wn is the unit weight for the $n^{th}$ parameter.

Qn is the sub index of $n^{th}$ parameter.

Table2: Showing Seasonal variation in physico-chemical parameters of two selected coal washeries effluents near Damodar River during November 2021 to October 2022

| Parameters | Moonidih Coal washery($S_1$) | | | Dugda coal washery ($S_2$) | | |
|---|---|---|---|---|---|---|
| | Range (Min-Max) | Mean | Standard Deviation | Range (Min-Max) | Mean | Standard Deviation |
| Temperature($^{0C}$) | 17.23-33.21 | 24.07 | 5.51 | 17.43-33.04 | 24.60 | 5.02 |
| pH | 7.21-8.98 | 8.1625 | 0.44 | 6.94-8.02 | 7.34 | 0.34 |
| EC(µs/cm) | 923-1239 | 1118.67 | 95.14 | 589.-1057 | 800.67 | 151.77 |
| Sulphate(mg/L) | 50.92-63.46 | 54.17 | 3.64 | 50.21-65.64 | 56.32 | 4.72 |
| Nitrate(mg/L) | 5.31-12.68 | 8.57 | 2.62 | 3.01-10.98 | 7.01 | 2.52 |
| Cl- (mg/L) | 62.89-105.96 | 78.39 | 11.70 | 53.01-94.01 | 72.58 | 13.75 |
| TDS (mg/L) | 551.96-1153.80 | 776.070 | 196.18 | 483.41-916.24 | 698.34 | 141.99 |
| Turbidity (NTU) | 24.11-34.61 | 29.56 | 2.87 | 18.34-32.43 | 24.432 | 4.46 |
| DO (mg/L) | 4.01-8.84 | 6.56 | 1.56 | 4.03-8.01 | 6.18 | 1.38 |
| BOD (mg/L) | 3.1-5.48 | 4.22 | 0.70 | 1.49-5.41 | 4.09 | 1.30 |

## Pearson's Correlation Coefficient

Pearson Co efficient Correlation determines the relation between two variables, depending upon the Correlation Coefficient expressed as r. The correlation coefficient values vary from +1 to −1, indicating varying interdependence. The r> 0.7 indicates a strong correlation between the variables (Ravi *et al*; 2021) The correlation is perfectly positive if the value (r) is +1 and correlation is perfectly negative If the value (r)is -1 and there is no correlation between the two variables, if the value (r)is 0.(Rodgers &Nice wander, 1998 and Magroliya *et al*; 2018).

The Karl Pearson's Correlation Coefficient (r) was calculated by using this equation (Zaidi and Pal 2015, Karmakar and Singh, 2021).

$$r = (n\ (\Sigma xy) - (\Sigma x)\ (\Sigma y)) / (\surd\ [n\ \Sigma x2 - (\Sigma x)2]\ [n\ \Sigma y2 - (\Sigma y)2)$$

Where
r = Pearson Coefficient
n = number of total observations
x& y =Two different variables
$\Sigma xy$ = sum of products of the variables
$\Sigma x$ = sum of the x variable in a sample
$\Sigma y$ = sum of the y variable in a sample
$\Sigma x2$ = sum of the squared x variable
$\Sigma y2$ = sum of the squared y variable

The correlation coefficient analysis was done in the study to know the relationship between the variables means various physico-chemical parameters used to indicate the quality of water (Kumar *et al*. 2005; P.Lilly Florece et al,2012).

In this study, Water Quality Index and Pearson correlation coefficient method were used as statistical tools to examine the physico-chemical parameters of the selected samples.

## RESULTS AND DISCUSSION

Various Physico-Chemical parameters were analyzed with the help of statistical tools of two coal washery effluents and got the result.

### Temperature

Temperature is one of the most important parameters to analyse the characteristic of waters. It controls the self-purification of water bodies pH and DO has a direct relation with the temperature. Temperature ranged between $17.23^{0C}$ to $33.21^{0C}$ in $S_1$ and $17.43^{0C}$ to $33.04^{0C}$ in $S_2$.

Maximum temperature was in the month of June and minimum during December in $S_1$ and January in $S_2$.

In $S_1$, temperature showed high significant positive relationship ($p<0.05$ level) with EC (r=0.97), TDS (r=0.989), $SO_4$-(r=0.82), Cl-(r=0.97).

Whereas pH(r=-0.903), $NO_3$- (r=-0.912), Turbidity (r=-0.279), DO (r=-0.928), BOD (r=-0.404) shows negative relationship at $p<0.05$ level.

In $S_2$, temperature showed high significant positive relationship

EC (r=0.98), TDS (r=0.98), $SO_4$-(r=0.94), Cl-(r=0.96).
Whereas pH(r=-0.81), $NO_3$- (r=-095), Turbidity (r=-0.9), DO (r=-0.95) BOD (r=-0.62). shows negative relationship at $p<0.05$ level.

### pH

PH means potential of Hydrogen is the parameter of to measure the acidic or basic nature of any aqueous solution. Extremely acidic or alkaline, both are problems to the ecosystem. The pH ranged from 7.21 to 8.98 in $S_1$ ( Near Moonidih coal washery) and from 6.94 to 8.02 in $S_2$ ( Near Dugda coal washery). Maximum pH was recorded during summer and minimum during winter season.

In $S_1$ pH shows significant positive relationship ($p<0.05$ level) with $NO_3$- (r=0.85), Turbidity (r=-0.43), DO (r=0.81) ,BOD (r=0.47).whereas EC (r=-0.8), TDS (r=-0.90), $SO_4^{2-}$(r=-0.69) Cl-(r=-0.87) shows negative relationship at $p<0.05$ level.

In $S_2$ pH shows high significant positive relationship ($p<0.05$ level) with $NO_3$- (r=0.77), Turbidity (r=-0.88), DO (r=- 0.67),BOD (r=0.59).whereas EC (r=-0.8), TDS (r=-0.79), $SO_4^{2-}$(r=-0.84) Cl-(r=-0.81) shows negative relationship at $p<0.05$ level.

### EC

Electrical conductivity or (EC) shows the ability of the water to conduct electrical current. The quantity of conductive ions presents in the water have significant impact on conductivity. In the present study, EC were found ranging from 923 µs/cm to 1239 µs/cm in $S_1$ and 589 µs/cm to 1057 µs/cm in $S_2$. Maximum EC was recorded during summer season.

In $S_1$ EC shows high significant positive relationship ($p<0.05$ level) with TDS (r=0.98), $SO_4$-(r=0.75), Cl-(r=0.990),
 whereas $NO_3$- (r=-0.847), Turbidity (r=-0.362), DO (r=-0.8606), BOD (r-=0.487) shows negative relationship at $p<0.05$ level.

In $S_2$ EC shows high significant positive relationship ($p<0.05$ level) with TDS (r=0.95), $SO_4$-(r=0.91), ,Cl- (r=0.93).whereas $NO_3$-(r=-0.96), Turbidity (r=--094),DO (r=- 0.9714), BOD (r=-0.66) shows high negative relationship at $p<0.05$ level.

### SO₄

Sulphate occurs in natural water and in waste water. The high concentration of Sulphate in natural water is usually caused by leaching of natural deposits of sodium Sulphate (Glauber's salt) and magnesium Sulphate (Epson Salt). In the present study So4 ranged from 50.74 mg/L to 64.62 mg/L in $S_1$ and from 50.21mg/L to 65.64mg/L in S2.

In $S_1$ So4 shows significant positive relationship ($p<0.05$ level) with TDS (r=811), Cl-(r=0.738), Whereas $NO_3$- (r=-0.78), Turbidity (r=-0.235). DO (r=-0.79), BOD(r=-0.40), shows negative relationship at $p<0.05$ level.

In $S_2$ So4 shows positive relationship ($p<0.05$ level) with TDS (r=0.94),Cl-(r=0.95).whereas $NO_3$- (r=-0.89), Turbidity (r=-0.84) DO (r=-0.83), BOD(r=-0.73), shows negative relationship at $p<0.05$ level.



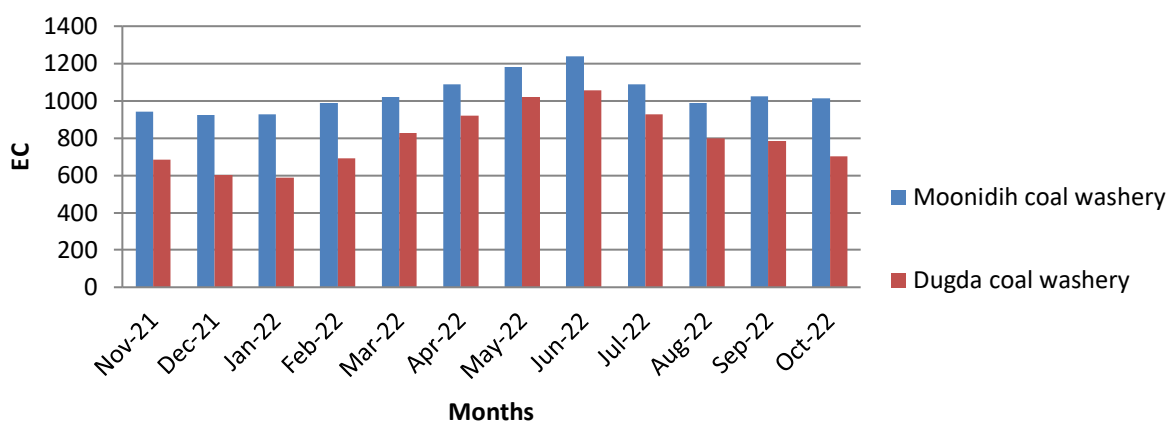[A] Temperature: Moonidih coal washery and Dugda Coal Washery effulent
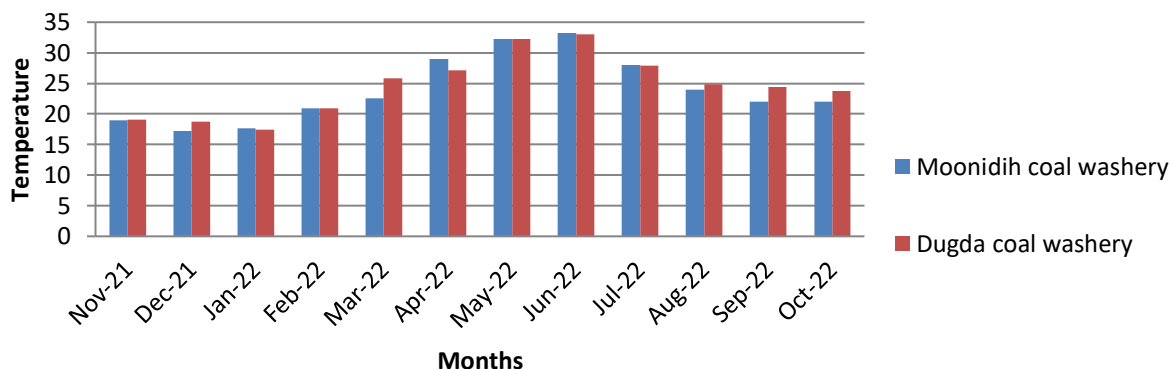
**[B] pH: Moonidih coal washery and Dugda Coal Washery effulent**
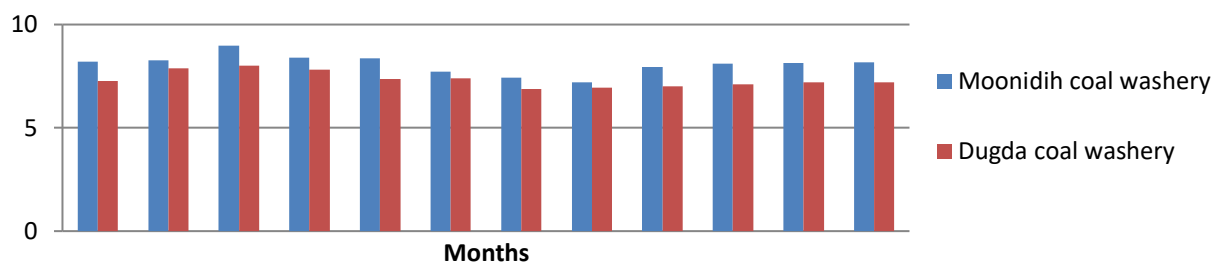
:

Legend: Moonidih coal washery, Dugda coal washery

Months



**[C] EC: Moonidih coal washery and Dugda Coal Washery effulent**

EC

Legend: Moonidih coal washery, Dugda coal washery

Months



**[D] SO$_4$: Moonidih coal washery and Dugda Coal Washery effulent**

SO$_4$

Legend: Moonidih coal washery, Dugda coal washery

Months

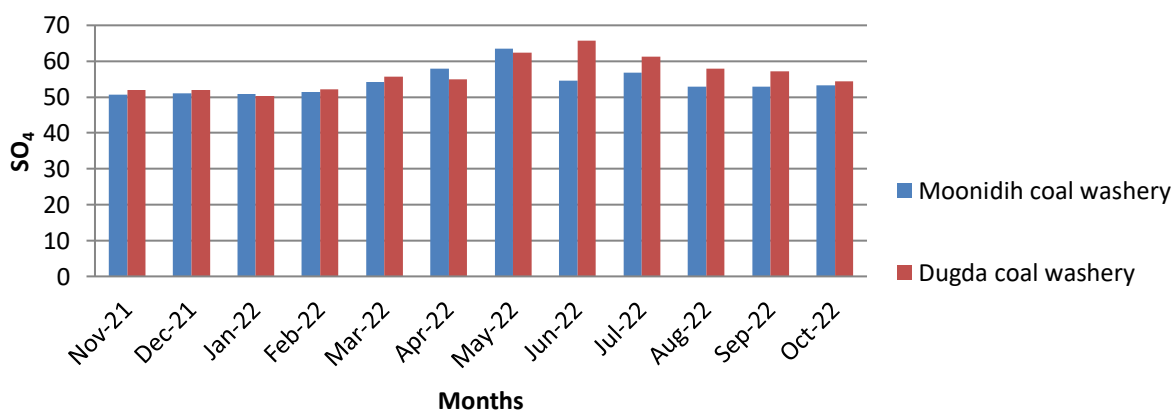# [E] NO3⁻: Moonidih coal washery and Dugda Coal Washery effulent



# [F] Cl⁻: Moonidih coal washery and Dugda Coal Washery effulent



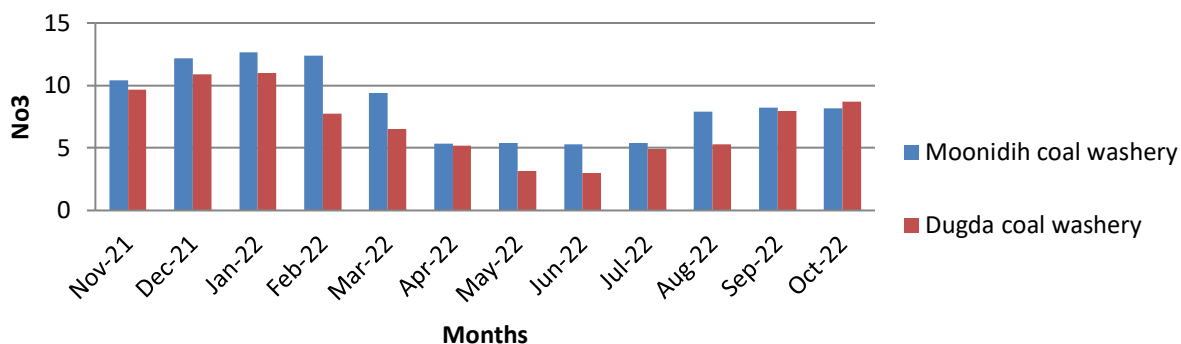# [G] T.D.S: Moonidih coal washery and Dugda Coal Washery effulent

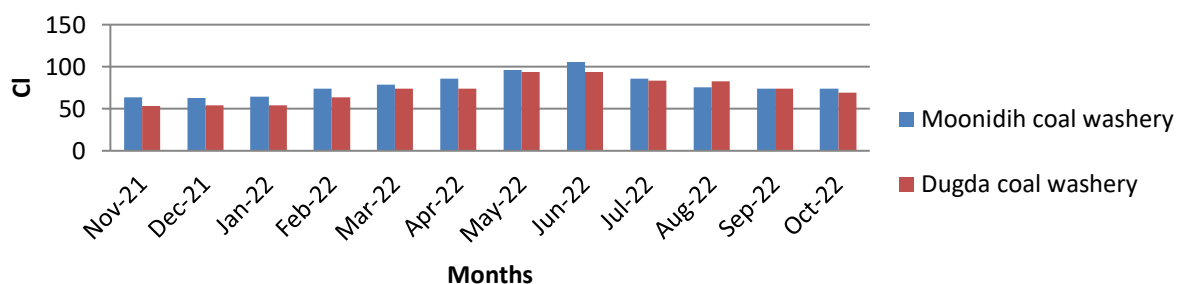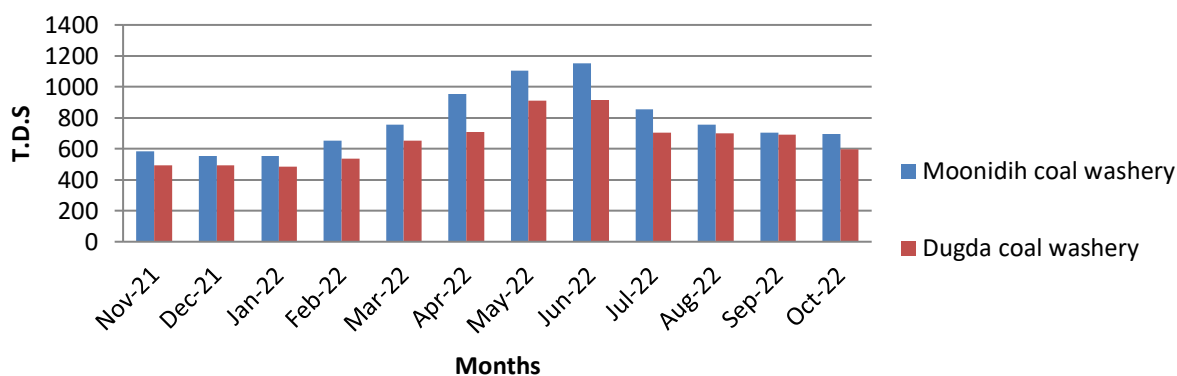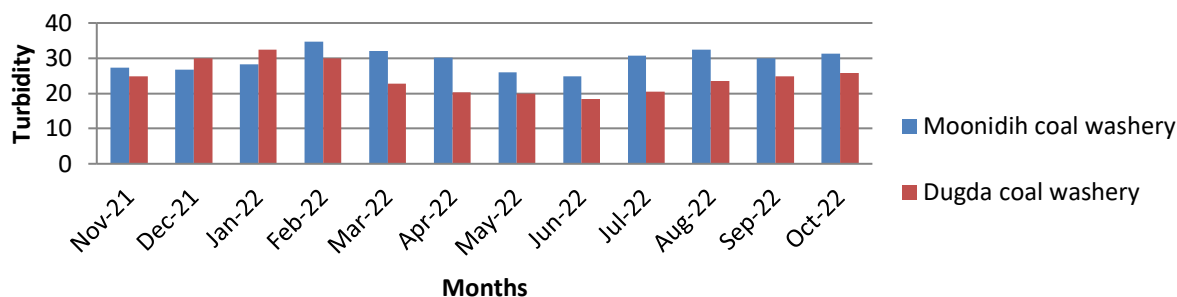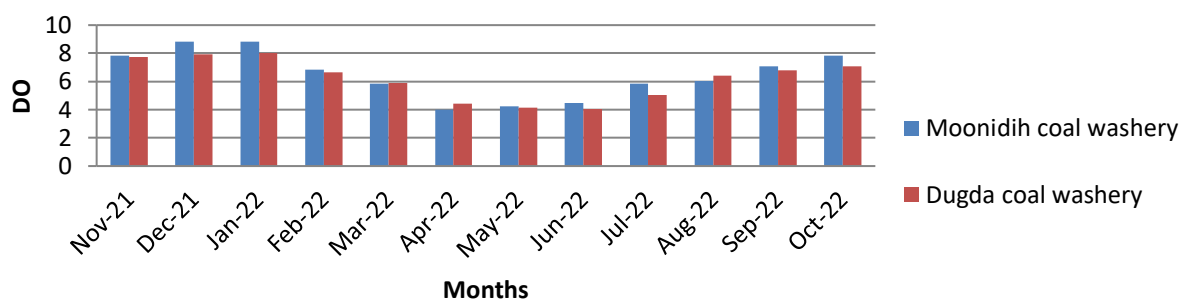## [H] Turbidity: Moonidih coal washery and Dugda Coal Washery effulent



## [I] DO: Moonidih coal washery and Dugda Coal Washery effulent



## [J] B.O.D: Moonidih coal washery and Dugda Coal Washery effulent
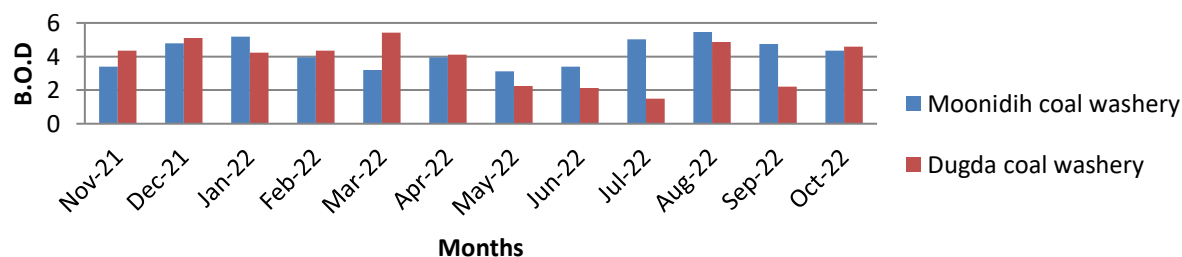


**Figure 1: Comparative graphical represtation of monthly variations in the Physico-Chemica Parameters of two selected Coal Washeries effluent [Moonidih Coal Washery(S1) and Dugda Coal Wahery (S2)] viz., [A]** Temperature; **[B]** pH; **[C]** Electrical Conductivity(EC); **[D]** Sulphate ($SO_4^-$); **[E]** Nitrate ($NO_3^-$); **[F]** Chloride ($Cl^-$); **[G]** Total Dissolved Solids(TDS); **[H]** Turbidity; **[I]** Dissolved OxygTen(DO); **[J]** Biochemical Oxygen Demand.

### Nitrate

Nitrate is one of the waters contaminates that mainly results from anthropogenic activity. The major resources are human or animal waste, sewage system, industrial waste, fertilizer application etc.

In the present study $NO_3^-$ ranged from 5.31mg/L to 12.68 mg/L in $S_1$ and from 3.01 mg/L to 10.98 mg/L in $S_2$.

In $S_{12}$ $NO_3^-$ shows high significant positive relationship (p<0.05 level) with Turbidity (r=0210), DO (r=0.39)BOD (r=0237). Wherea

TDS (r=-0.83), Cl-(r=0-87), shows negative relationship at p<0.05 level.

In $S_2$ $NO_3^-$ shows significant positive relationship (p<0.05 level) with Turbidity (r=-0.8657), DO (r=0.879, BOD (r=0.4494). whereas TDS (r=0.9329), Cl-(r=0.9029), shows negative relationship at p<0.05 level.

**Chloride**

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl) and calcium ($cacl_2$). Chlorides are leached from various rocks into the soil and water by weathering. The presence of a significant amount of organic matter with both allochthonous and autochthonous origin may be the cause of the elevated chloride concentration.

In the present study Cl- ranged from 62.89 mg/L to 105.96 mg/L in $S_1$ and from 53.01 mg/L to 94.01 mg/L in $S_2$.

In $S_1$ Cl- shows positive relationship (p<0.05 level) with TDS (r=0.983), whereas Turbidity (r=-0.2901), DO (r=- 0.8882) BOD (r=-0.463 shows negative relationship at p<0.05 level.

In $S_2$ Cl- shows significant positive relationship (p<0.05) with TDS (r=0.9643). Whereas Turbidity (r=-0.84),DO (r=- 0.89) BOD (r=-0.62) shows negative relationship at p<0.05 level.

**Table 3: Corelation Matrix (Pearson's correlation method) among physico- chemical parameters of Damodar River water near Moonidih Coal Washery ($S_1$).**

|         | Temp | pH | E C | $SO_4^-$ | $NO_3^-$ | Cl- | T.D. S | Turbidity | D.O | B.O D |
|---------|------|----|-----|----------|----------|-----|--------|-----------|-----|-------|
| Temp | 1 | | | | | | | | | |
| pH | -0.90322 | 1 | | | | | | | | |
| E C | 0.97005 | -0.8977 | 1 | | | | | | | |
| $SO_4^{2-}$ | 0.82168 | -0.69619 | 0.753335 | 1 | | | | | | |
| $NO_3^-$ | -0.91213 | 0.855036 | -0.84747 | -0.78115 | 1 | | | | | |
| Cl- | 0.97435 | -0.87572 | 0.990576 | 0.738256 | -0.83506 | 1 | | | | |
| T.D.S | 0.989697 | -0.90897 | 0.979963 | 0.81154 | -0.87316 | 0.983189 | 1 | | | |
| Turbidity | -0.27924 | 0.437995 | -0.36196 | -0.23574 | 0.210911 | -0.29009 | -0.34468 | 1 | | |
| D.O | -0.928 | 0.814055 | -0.86057 | -0.79621 | 0.839193 | -0.88822 | -0.92159 | 0.06737 | 1 | |
| B.O.D | -0.40453 | 0.473992 | -0.48725 | -0.39948 | 0.237523 | -0.46316 | -0.47096 | 0.287315 | 0.473953 | 1 |

**Table 4: Corelation Matrix (Pearson's correlation method among physico- chemical parameters of Damodar River water near Dugda Coal Washery($S_2$)**

|         | Temp | pH | E C | $SO_4^-$ | $NO_3$ | Cl- | T.D. S | Turbidity | D.O | B.O.D |
|---------|------|----|-----|----------|--------|-----|--------|-----------|-----|-------|
| Temp | 1.0 | | | | | | | | | |
| pH | -0.81 | 1.0 | | | | | | | | |
| E C | 0.98 | -0.8 | 1.0 | | | | | | | |
| $SO_4^-$ | 0.94 | -0.84 | 0.91 | 1.0 | | | | | | |
| $NO_3^-$ | -0.95 | 0.77 | -0.96 | -0.89 | 1.0 | | | | | |
| CT | 0.96 | -0.81 | 0.93 | 0.95 | -0.96 | 1.0 | | | | |
| T.D.S | 0.98 | -0.79 | 0.95 | 0.94 | -0.93 | 0.96 | 1.0 | | | |
| Turbidity | -0.9 | 0.88 | -0.94 | -0.84 | 0.89 | -0.84 | -0.85 | 1.0 | | |
| D.O | -0.95 | 0.67 | -0.97 | -0.83 | 0.95 | -0.89 | -0.9 | 0.88 | 1.0 | |
| B.O. D | -0.62 | 0.59 | -0.66 | -0.73 | 0.56 | -0.62 | -0.65 | 0.53 | 0.58 | 1.0 |

## TDS

Total Dissolved Solids demonstrates just the measure of distinct disintegrated solids. It is mainly due to vegetative decay, evaporation and disposal of effluents etc.

In the present study TDS ranged from 551.96 mg/L to 1153.80 mg/L in S1 and from 483.41 mg/L to 916 mg/L in $S_2$.

In $S_1$ TDS shows negative relationship at (p<0.05 level) with Turbidity (r=-0.34), DO (r=-0.92) and BOD (r =- 0.47) at (p<0.05 level).

In $S_2$ TDS shows negative relationship at (p<0.05 level) with Turbidity (r=-0.85), DO (r=-0.90) and BOD (r =- 0.65).

## Turbidity

Turbidity in water is the reduction of transparency due to presence of particular matter, such as clay or slit, finely divided organic matter etc.

In the present study Turbidity ranged from 24.91 NTU to 34.61 NTU in $S_1$ and from 18.34 NTU to 32.43 NTU in $S_2$.

In $S_1$ Turbidity shows positive relationship at (p < 0.05 level) with DO (r = 0.067), BOD (r = 0.287). In $S_2$ Turbidity shows positive relationship at (p< 0.05 level) with DO (r =0.88) and BOD (r =-0.53).

**Table 5: Calculated WQI (Water Quality Index) for the two sites i.e Near Moonidih Coal Washery(S1) and Near Dugda Coal Washery (S2).**

| | Parameter | BIS STD (Sn) | K=1/1/Sn | Wn=K/Sn | QN=Vn/Snx100 | WnQN |
|---|---|---|---|---|---|---|
| Moonidih Coal Washery ($S_1$) | pH | 8.5 | 2.831 | 0.3321 | 77.5 | 25.74 |
| | DO | 5 | 2.831 | 0.5662 | 94.44 | 53.45 |
| | EC | 300 | 2.831 | 0.00944 | 372.89 | 3.52 |
| | TDS | 500 | 2.831 | 0.00566 | 155.21 | 0.88 |
| | $SO_4^{2-}$ | 250 | 2.831 | 0.01132 | 21.67 | 0.25 |
| | Cl- | 250 | 2.831 | 0.01132 | 31.36 | 0.35 |
| | $NO_3^-$ | 45 | 2.831 | 0.06291 | 19.04 | 1.20 |
| | | | | | | WnQn= 85.39 |
| Dugda Coal Washery ($S_2$) | pH | 8.5 | 2.831 | 0.332 | 22.67 | 7.53 |
| | DO | 5 | 2.831 | 0.5662 | 87.71 | 49.68 |
| | EC | 300 | 2.831 | 0.00944 | 266.89 | 2.52 |
| | TDS | 500 | 2.831 | 0.00566 | 139.67 | 0.79 |
| | $SO_4^{2-}$ | 250 | 2.831 | 0.01132 | 22.53 | 0.255 |
| | Cl- | 250 | 2.831 | 0.01132 | 29.03 | 0.33 |
| | $NO_3^-$ | 45 | 2.831 | 0.06291 | 15.58 | 0.98 |
| | | | | | | WnQn=62.09 |

**Table 6: Categories for Water Quality Status developed by Brown *et al*.,1972**

| Water Quality Index | Water Quality Status | Possible application |
|---|---|---|
| 0-25 | Excellent | Drinking, Irrigation and Industrial |
| 26-50 | Good | Drinking, Irrigation and Industrial |
| 51-75 | Poor | Irrigation and Industrial |
| 76-100 | Very Poor | Irrigation |
| >100 | Unfit for consumption | Proper treatment required before use |

## D O

Dissolved oxygen (DO) plays an important role in the growth, survival, behavior, dispersion and metabolic process of fishes and other aquatic organism. The desirable limit of DO according to standard method BIS ranges from 4mg/L to 6mg/L .

Here DO range from 4.01mg/L to 8.83 mg/L in $S_1$ and from 4.03 mg/L to 8.01 mg/L in $S_2$.

In $S_1$ DO shows positive relationship (p<0.05 level) with BOD (r= 0.47) and it shows positive relationship with BOD (r=o.58) in $S_2$.

## BOD

It is a measure of the quantity of oxygen consumed by microorganisms during the composition of organic matter.

In the present study BOD ranged from 3.1 mg/L to 5.48 mg/L in $S_1$ and from 1.49 mg/L to 5.41mg/L in $S_2$.

## RESULTS
### WQI

WQI (Water Quality Index), which are used to know the quality status of any aquatic Ecosystem. WQI is computed in a few steps and got the result.(Sharma &Kansal,2011,Kumar&Dua 2009)

Calculated WQI indicates that both the sampling sites fall under very poor and poor categories at developed by Brown et al, 1972.

Moonidih coal washery shows 85.39 WQI value which is higher than Dugda coal washery WQI value that is 62.09.

Water Quality Index is a numerical representation of the overall water quality suitable for various purposes. AS a result, we can see that both the sites (S1-Moonidih Coal washery and S2 – Dugda coal washery effluents) were not suitable for drinking and other purposes. Also, and it is not suitable for aquatic animals to survive. It is necessary to do proper treatment for its use in different purposes.

## CONCLUSION

The present investigation provides an overall picture on the water quality status of the two sites of Damodar River viz   Near Moonidih coal washery (S1) and Near Dugda coal washery (S2) with the help of various physico- chemical analysis and statistical tools like WQI and Pearson 's coefficient correlation method.

Analysis of monthly variation sanctioned in the physico- chemical parameters such as Temperature, pH, EC, TDS, $SO_4^{2-}$, $NO_3^-$, Cl-, BOD, DO, Turbidity were found to be in higher concentration compare to permissible limit  WHO  (2006) in both the sites, but it was higher in S1 ( Near  Moonidih coal washery).

WQI shows very poor to poor quality status of S1 and S2 respectively.

So, on the basis of the above results, it can be concluded that with proper treatment and regular water monitoring by competent authorities can improve the water quality and river water can be utilized for different purposes, and it should be beneficial for the local people living there nearby.

## REFERENCES

- **APHA. (2005)**, Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington, DC.
- **Bell, F. C., and Kerr, A. (1993**). Coal mining and water quality with illustration from Britain, *Env-Management ,Geo - water of Engineering Aspects* page 607 – 614.
- **Bhandari, N.S. and Nayal, K.( 2008)**. Correlation Study on Physico-chemical Parameters and Quality Assessment of Kosi River Water,Uttarakhand. *Electronic J.  Chemistry*. 5: 342-346.
- **Bhattacharya, K. (2011).** Status of aquatic ecosystem and pollution in the Damodar River basin, India. *Journal of Environmental Research and Development*, 5(4), 987-993.
- **BIS. (2012).** Indian Standard Specification for Drinking Water , Bureau of Indian Standards.
- **Brown, R.M., McClelland, N.I., Deininger, R.A. and Tozer, R. G.(1970)**. A Water quality Index – Do we dare? *Water and SewageWorks*. 339-343.
- **Chandra, S. (2003**). Water quality deterioration due to coal washeries in Damodar basin: Case study from Bokaro. *Environment and Ecology*, 21(4), 787-791.
- **Ghosh, N., Dhar, M. K., and Ghosh, S. (1993).** Heavy metal contamination in Damodar River basin due to industrial discharges. *Indian Journal of Environmental Health*, 35(4), 282–288.
- **Hardgrave, B.C., Wilson, R.L. and Walstrom, K.A. (1994).** Predicting Graduate Student Success: A Comparison of Neutral Networks and Traditional Techniques. *Computers and Operations Research*. 21:249-263.
- **IS 10500:2012**. Bureau of Indian Standards, Standards for Drinking Water.
- **Karmakar, B. and Singh, M. K. (2021**). Assessment of Water Quality Status of Water Bodies Using Water Quality Index and Correlation Analysis in and Around Industrial Areas of West District, Tripura,India. *Nature Environment and Pollution Technology*. 20(2): 551-559.
- **Khan, M. A., Danish, M., Ahmad, M., and Akhtar, M. S. (2003).** Statistical correlation of physicochemical parameters of ground water in Aligarh city, *Pollution Research*,22(4),553-556.
- **Kumar, A., and Dua, A. (2009**). Water quality index for assessment of water quality of river Ravi at Madhopur. *Global Journal of Environmental Sciences,* 8(1), 49-55.
- **Kumar, J., Jana, A.K., Bansal, A. and Garg, R.( 2005).** Development of correlation Between BOD and COD for refinery    waste. *Indian J.Environmental Protection*. 25(5): pp 405-409.
- **Lilly, F., Paulraj, A. and Ramachandramoorthy, T. (2012).** Water Quality Index and Correlation Study for the Assessment of Water Quality and its Parameters of Yercaud Taluk, Salem District, Tamil Nadu, India.*Chemical Sciences Transactions*. 1(1): 139-149.
- **Magroliya, Vasundhara, and Trivedi, M.( 2018).** Statistical Correlation and Seasonal Comparative Study of Groundwater Samples of Jaipur.*Environ Risk Assess. Remediate*. 2(3).
- **Mishra, S and Singh, P. (2021**). Studies on the Physico-chemical Parameters and Correlation coefficient of Govindgarh Lake, Rewa (M.P.). *International J. Advanced Academic Studies*. 3(2): 34-38.
- **Ravi, S., Sharma, M., and Rani, P. (2021**). Comprehensive water quality assessment of the Hindon River using water quality index and GIS techniques. *Environmental Challenges*, 5, 100334. https://doi.org/10.1016/j.envc.2021.100334
- **Rodgers; Nice wander, 1988**. "Thirteen ways to look at the correlation coefficient" (PDF). *The American Statistician*. 42 (1): 59– 66.
- **Sargaonkar, A.,  Deshpande, V. (2003**). Development of an overall index of pollution for surface water based on a general classification scheme in Indian context. *Environmental Monitoring and Assessment*, 89(1), 43–67. https://doi.org/10.1023/A:1025886025137.
- **Sen, P. K. (1991**). Pollution study of the Damodar River in Dhanbad–Bokaro industrial belt. *Pollution Research*, 10(2), 101–105.
- **Sharma, D., and Kansal, A. (2011**). Water quality analysis of River Yamuna using water quality index in the national capital territory, India (2000–2009). *Applied Water Science*, 1, 147–157. https://doi.org/10.1007/s13201-011-0011-4
- **Singh, G., Sinha, A., and Srivastava, R. K. (2013**). Impact of industrial effluents on the water quality of Damodar River in Bokaro industrial region. *International Journal of Environmental Sciences*, 4(1), 63–72.
- **Singh, R. P., and Kamal, R. (2014).** Assessment of surface water quality in the vicinity of coal mining areas: A case study from Damodar River, Bokaro, Jharkhand. *Indian Journal of Environmental Protection,* 34(5), 410–417.
- **Tripathi, B., Pandey, R., Raghuvanshi, D., Singh, H., Pandey, V. and D.N.( 2014).** Studies on the Physico-chemical Parameters and Correlation Coefficient of the River Ganga at Holy Place Shringverpur,Allahabad. I*OSR J. Environmental Science, Toxicology and Food Technology (IOSR- JESTFT)*. Vol. 8. 10(1): 29-36.
- **Tiwari, T. N., and Mishra, M. A. (1985**). A preliminary assignment of water quality index of major Indian rivers. *Indian Journal of Environmental Protection*, 5(4), 276–279.
- **Tyagi, S., Sharma, B., Singh, P., and Dobhal, R. (2013).** Water quality assessment in terms of water quality index. *American Journal of Water Resources*, 1(3), 34–38. https://doi.org/10.12691/ajwr-1-3-3
- **Yisa, J., and Jimoh, T. (2010).** Analytical studies on water quality index of river Landzu. *American Journal of Applied Science*, 7(4), 453–458.

- **Zaidi, J. and Pal, A. (2015).** Influence of Temperature on physico-chemical Properties of Fresh Water Ecosystem of Bundelkhand Region of Uttar Pradesh, India. *Int. J. Curr. Res. Chem. Pharma. Sci*. 2(3)1-8.