

PREMONSOON, MONSOON, POSTMONSOON EVALUATION OF WATER QUALITY OF ARPA RIVER AT BILASPUR TOWNSHIP (C.G.) INDIA

M.M. Vaishnav¹, A.K.Mishra ^{2*}, D.P. Sahu³ and S. Dewangan⁴

1. Deptt. Of Chemistry, Govt.G.B,College,Hardibazaar,Korba (C.G.) India

2. Deptt. Of Chemistry, Govt.Bilasa Girls P.G.,College, Bilaspur (C.G.) India

3. Deptt. Of Chemistry, Govt. E.R.R.P.G. Science College, Bilaspur (C.G.) India

4. Deptt. Of Chemistry, Govt. Minimata P.G. College, Korba (C.G.) India

Abstract

In continuation of our previous work, we have taken the comprehensive study of Arpa river water at Bilaspur township. In this context, we have evaluated the statistical data of various parameters; water quality and heavy metallic elements in postmonsoon(2021), premonsoon (2022) and monsoon (2022). The finding results of the same parameters viz, Turbidity TA, TH, Fluoride and heavy metal were reported beyond the standard Limit; Stipulates by the BIS (2012) and WHO (2011) standard. The correlation matrix was also calculated between various variable parameters. The high correlation was established between Temp. vs TS ($r = +0.8232$), pH vs Hg ($r = +0.9073$), TDS vs Hg ($r = +0.8415$), TA vs Hg ($r = -0.802$). The WQI was too much high which ranges, between 143.02 (BC₈) to 9826.92 (BC₉) in premonsoon and in monsoon the ranges covered 101.21(BC₉) to 175.4(BC₂) and in postmonsoon the ranges were 252.23 (BC₂) to 13693.00 (BC₁₀) were calculated, which indicated the water quality of the selected area are very high degree polluted.

Introduction:

Environment is related to the surrounding of global environment, which consists of atmosphere (21% O₂ and 78% N₂), lithosphere and hydrosphere; these three parts are sustaining resources of the earth planet¹. Water is a vital source and reflexed by their physico-chemical and microbiological characters². The chemical constituents of water is vital criteria, that decide the quality of water^{3,4}. Water is a basic cum fundamental materials of the living organism; Animals, plants, humans and microorganisms; bacteria and virus etc. and also basic needs of the holistic developments of whole globe; Industrial and agricultural sector, house holding application^{5,6,7}. 79% areas of the earth planet is occupied by the aquatic system such as seas, oceans, lakes, water streams, rivers, creeks, reservoirs, open wells and glaciers. The percentage of free water is less than one percentage. These aquatic systems now became contaminated by the additive such as industrial effluents, agricultural runoffs, domestic sewage etc.^{8,9}.

*Address for correspondence: ashishkumarmishraasi@gmail.com

We have taken systematic and scientific study of Arpa river water and their tributary; Gokhanea nallahs and Kharun river, as per physico-chemical toxic elements point of view. The river origin; Khondari Khongsara, G-P-M district and flow 147 km with catchment areas with 202 sq. km and joined shivnath river. Arpa river is life line of Bilaspur township, which make north and south of Bilaspur. At the bank of the river and their subsidiary rivers. Numbers of industrial major and minor units have located. Agricultural runoffs, Industrial effluents, domestic sewage continue to discharge in this river systems as resulting the water of these rivers become high degree contaminated. In continue of our previous publication cum project ¹⁰⁻¹⁴, we have consider for the scientific exploration of Arpa river water system. In the paper, we have focused the periodical assessment of Arpa river water system.

Objectives:

The main objectives of this project are as follows:

- 1) To survey of the sampling spots and collection of the surface water in preclean water bottles.
- 2) To analysis of physico-chemical qualities with selected heavy metals by the ICP-MS technique.
- 3) To evaluation of the experimental value by the statistical parameters.

Materials and Methods:

The water samples were collected from the ten sampling spots ; assigned from BC₁ to BC₁₀ in DD washed and 5% HNO₃ sterilized polythene bottle in the period of post-monsoon (2021), pre-monsoon and monsoon (2022). The physical parameters were analysed instantly on the spot by the electronic analyser, remaining parameters were calculated by the standard method ¹⁵⁻¹⁸ in CCOS laboratory. Selected heavy metals, Fe, Cd, Hg, As, Cr by the ICP-MS technique in Birla research institute Mersa Ranchi (J.H.) The statistical parameters of experimental values are given in Table -I and Table II.

Table Ia = Postmonsoon 2021 statistical parameters

Sr.No	Parameters	Ranges	Min.	Max.	Mean	Std.Dev.	%CV	Std.Error
1.	Temperature	18.4-23.8	18.4	23.8	26.7	0.00	0.00	0.00
2.	pH	6.5-7.0	6.5	7.0	6.69	0.12	0.02	0.04.
3.	EC	0.35-2.81	0.35	2.81	0.86	0.18	0.21	0.06
4.	TS	247-372	247	372	686.30	44.86	0.07	14.18
5.	TDS	160-570	160	570	436.50	71.19	0.16	22.51
6.	TSS	263-130	263	130	249.80	85.01	0.34	26.88
7.	Turbidity	>0.3125->5	>0.3125	>5	4.00	4.00	4.00	4.00
8.	Total Hardness	112.40-256.50	112	331.5	204.51	76.70	0.38	24.25
9.	Total alkalinity	243.25->250	243.25	>250	>250	NA	NA	NA
10.	Cholride	259-350	259	350	424.20	100.92	0.24	31.91
11.	Nitrate	12.16-65.00	12.16	65.00	52.43	26.43	0.50	8.36
12.	Sulphate	02.09-223.01	02.09	223.01	85.30	57.37	0.67	18.14
13.	Fluoride	BDL-0.417	BDL	0.417	0.50	0.092	0.230	1.046
14.	Sulphide	0.024-0.074	0.024	0.074	3.9	NA	NA	NA
15.	DO	147.8-181.1	147.8	181.1	183.13	6.82	0.04	2.16
16.	M.V.	-973.6-1203.4	-973.6	1203.4	-1017.46	24.51	-0.02	7.75
17.	Salinity	0.271-2.14	0.271	2.14	0.65	0.14	0.21	0.04
18.	Na	17.8-71.5	17.8	71.5	68.57	29.22	0.43	9.24
19.	K	3.3-21.5	3.3	21.5	17.20	17.20	17.20	17.20
20.	As	BDL-0.202	BDL	0.202	0.16	0.22	1.35	0.07
21.	Cr	0.001-0.248	0.001	0.248	0.06	0.05	0.80	0.02
22.	Hg	BDL-0.202	BDL	0.202	0.2	0.2	1.14	0.01
23.	Cd	0.005-0.017	0.005	0.017	0.01	0.01	0.85	0.0
24.	Free Chlorine	>0.125->0.125	>0.125	>0.125	0.01	0.01	0.85	0.00
25.	Fe	0.005-0.230	0.005	0.230	0.05	0.5	0.59	0.02
26.	BOD	2-00	2	00	7.31	1.71	0.23	0.54
27.	COD	3-15	3	15	12.93	1.43	0.11	0.45

Table Ib = pre-monsoon 2022 statistical parameters

Sr.No	Parameters	Ranges	Min.	Max.	Mean	Std.Dev.	%CV	Std.Error
1.	Temperature	26.7-26.7	26.7	26.7	26.7	0.00	0.00	0.00
2.	pH	6.45-7.0	6.45	7.00	6.69	0.12	0.02	0.04.
3.	EC	0.368-1.242	0.368	1.242	1.223	0.18	0.21	0.06
4.	TS	599-784	599	784	686.30	44.86	0.07	14.18
5.	TDS	220-560	220	560	436.50	71.19	0.16	22.51
6.	TSS	98-449	98	449	249.80	85.01	0.34	26.88
7.	Turbidity	0.3125-5000	0.3125	5.00	4.00	4.00	4.00	4.00
8.	Total Hardness	118.41-331.5	118.41	331.5	204.51	76.70	0.38	24.25
9.	Total alkalinity	250->250	>250.0	>250	>250	NA	NA	NA
10.	Cholride	299-978	299	978	424.20	100.92	0.24	31.91
11.	Nitrate	10.76-129.03	10.76	129.03	52.43	26.43	0.50	8.36
12.	Sulphate	1.59-325.45	1.59	325.45	85.30	57.37	0.67	18.14
13.	Fluoride	0.092-1.553	0.092	1.553	0.5024	0.092	0.230	1.046
14.	Phosphate	0.5-7.3	0.5	7.3	1.38	NA	NA	NA
15.	DO	173.8-199.6	173.8	199.6	183.125	6.82	0.04	2.16
16.	M.V.	-919.5--1066.8	-919.5	-1066.8	-1017.4	24.51	-0.02	7.75
17.	Salinity	0.273-0.923	0.273	0.923	0.6462	0.14	0.21	0.04

18.	Na	14.8-114	14.8	114	68.57	29.22	0.43	9.24
19.	K	3.5-19.4	3.5	19.4	11.58	17.20	17.20	17.20
20.	As	0.001-0.605	0.001	0.605	0.1794	0.22	1.35	0.07
21.	Cr	0.001-0.303	0.001	0.303	0.06316	0.05	0.80	0.02
22.	Hg	0.001-0.243	0.001	0.243	0.05454	0.2	1.14	0.01
23.	Cd	0.004-0.1	0.004	0.1	0.0167	0.01	0.85	0.0
24.	Cr	0.001-0.06	0.001	0.06	0.02268	0.01	0.85	0.00
25.	Fe	0.005-0.306	0.005	0.306	0.0895	0.5	0.59	0.02
26.	BOD	3.5-11	3.5	11	7.31	1.71	0.23	0.54
27.	COD	9.41-15	9.41	15	12.48	1.43	0.11	0.45

Table Ic = monsoon 2022 statistical parameters

Sr. No	Parameters	Ranges	Min.	Max.	Mean	Std.De v.	%CV	Std.Er ror
1.	Temperature	24.2-25.7	24.2	25.7	26.7	0.00	0.00	0.00
2.	pH	5.8-7.0	5.8	7.0	6.69	0.12	0.02	0.04.
3.	EC	125-199.8	125	199.8	0.86	0.18	0.21	0.06
4.	TS	225-408	225	408	686.30	44.86	0.07	14.18
5.	TDS	81.2-310	81.2	310	436.50	71.19	0.16	22.51
6.	TSS	94-299.8	94	299.8	249.80	85.01	0.34	26.88
7.	Turbidity	0.323->5	0.323	->5	4.00	4.00	4.00	4.00
8.	Total Hardness	110.016-254.89	110.016	254.89	204.51	76.70	0.38	24.25
9.	Total alkalinity	136->250	136	250	>250	NA	NA	NA
10.	Cholride	>62.5-340	>62.5	340	424.20	100.92	0.24	31.91
11.	Nitrate	BDL-100.647	BDL	100.647	52.43	26.43	0.50	8.36
12.	Sulphate	BDL-163.19	BDL	163.19	85.30	57.37	0.67	18.14
13.	Fluoride	0.102-5.178	0.102	5.178	0.50	0.092	0.230	1.046
14.	Phosphate	0.10-1.21	0.10	1.21	3.9	NA	NA	NA
15.	DO	135.4-242.6	135.4	242.6	183.13	6.82	0.04	2.16
16.	Sulphide	>0.1->0.30	>0.1	>0.30	---	---	---	--
17.	M.V.	-772.5- -992.6	772.5	992.6	1017.46	24.51	-0.02	7.75
18.	Salinity	93.6-155.3	93.6	155.3	0.65	0.14	0.21	0.04
19.	Na	11.0-28.8	11.0	28.8	68.57	29.22	0.43	9.24
20.	K	2.4-5.6	2.4	5.6	17.20	17.20	17.20	17.20
21.	As	BDL-0.404	BDL	0.404	0.16	0.22	1.35	0.07
22.	Cr	BDL-0.1200	BDL	0.1200	0.06	0.05	0.80	0.02
23.	Hg	BDL-BDL	BDL	BDL	0.2	0.2	1.14	0.01
24.	Cd	BDL-0.013	BDL	0.013	0.01	0.01	0.85	0.0
25.	Fe	0.007-0.318	0.007	0.318	0.05	0.5	0.59	0.02
26.	BOD	2-9	2	9	7.31	1.71	0.23	0.54
27.	COD	3-8	3	8	12.93	1.43	0.11	0.45

Results & Discussion

The analytical assessment has been done of the collected Water samples (surface water system; Arpa river, gokhnae nallah and Kharun river). Ten sampling spots were choosed and analysed for different: Physical Chemical and selected metallic elements. The results have been procured from postmonsoon 2021, premonsoon-2022 and monsoon-2022.

The obtained results are discussed in the following subheading.

Temperature: Temperature is a important physical parameters, which standard value in 7⁰C to 11⁰C as per norms of water testing agencies; Bis (2012)¹⁹ and WHO (2011)²⁰. In study field and period; Post monsoon 2021 min. value noted down 18.4⁰C (BC₁) and max. value was recorded 23.8⁰C. In premonsoon 2022 min. value was 26.7⁰ at all. Located position while in monsoon 2022 the min. value was observed at 24.2 (BC₇). The time is high in premonsoon season 2022 due to high atmospheric temperature.

pH: The nature of water; Acidic, basic and neutral in reflexed by the pH. In study period and location the pH is measured by the pH metry. The obtained results for postmonsoon 2021, premonsoon-2022 and monsoon 2022; min. 6.5 (BC₁) max. 7.00 (BC₁₀), min. 6.45 (BC₁) and 7.00 (BC₈). Min. 5.8 (BC₃) max. (BC₁₀). The spot (BC₃) has lowest pH which is from away farm the standard value as per BIS (2012)¹⁹ and WHO (2011)²⁰ : 6.5 to 8.50 The nature of water of BC₃ has slightly acidic in nature which remains water samples of the selected spots are neutral in nature.

EC: Electrical conductivity measure is the dissolve ions and measured by the conductivity meter. At the period of investigation, the experimental values recorded for EC in the post monsoon 2021. Premonsoon-2022 and monsoon - 2022 as min. and max. 0.368 (BC₁), 1.242 (BC₅), 125(BC₄), 199.8 (BC₉) and 0.35 (BC₃) 2.81 (BC₄) orderly. The high value was note down in premonsoon season due to high evaporation of wates as resulting increase the concertation of dissolve ions.

TS: This physical parameter measures the dissolve and suspended particulate matter in aquatic system. The results obtained with experimental value in different session postmonsoon -2021 247 mgL⁻¹ (BC₃) and 327 mgL⁻¹ (BC₆) in Premonsoon 599 mgL⁻¹ (BC₉) and 784 mgL⁻¹ (BC₃). In monsoon 2022 225 mgL⁻¹ (BC₁) and ios mgL⁻¹ (BC₅). The obtained results are above the desirable limit while below the maximum value as per BIS (2012)¹⁹ and WHO (2011)²⁰, drinking water agency.

TDS: Total dissolved solid is reflex only dissolved ions in water. It is directly corelated to EC. The measurement results were categories as postmonsoon 2021 as min. 160 mgL⁻¹ (BC₂) and max. 570 mgL⁻¹ (BC₁₀), premonsoon - 2022 as low ions. 220 mgL⁻¹ (BC₁) and 560 mgL⁻¹ (BC₆) while monsoon 2022 the min canc. was seen 81.2 mgL⁻¹ (BC₄) and 310 mgL⁻¹ (BC₈). All these value are above the desirable and below the max. threshold value.

Turbidity: Turbidity is measure the suspended particles in wate samples. At the period of search. We have measured the value of turbidity in postmonsoon 2021 as 0.3125 NTU (BC₆) and max. >5 NTU (BC₁) in premonsoon 2022 as

min. 0.3125 (BC₆) as 5.00 NTU (BC₁) while in monsoon-2022. 0.323(BC₄) and >5 (BC₇) as for entire these value are above the excessive permissible limit as per BIS (2012)¹⁹ and WHO (2011)²⁰ respectively.

Total Hardness:- Total hardness is defined as the concentration of multivalent metallic cations in solution. Hardness of water is only due to Ca⁺² and Mg⁺² ion. In observation period; postmonsoon-2021, premonsoon-2022 and monsoon-2022. The finding result are 112.40 mgL⁻¹ (BC₁) and 371.50 mgL⁻¹ (BC₈); 118.41 mgL⁻¹ (BC₁) and 331.5 mgL⁻¹ (BC₁₀), 110.016 mgL⁻¹ (BC₂) and 254.89 mgL⁻¹ (BC₇). The highest value indicated water is associated with hard water.

Total alkalinity:- The total alkalinity of water sample is due to dissolve of hydroxide, carbonate and bicarbonate ion in water sources. Total alkalinity was measured by the volumetric technique, with the results in postmonsoon 2021 on 243.25 (BC₇) as minimum and as max. >250 mgL⁻¹ (BC₁) while in premonsoon-2022, all sampling spots having same conc. of total alkalinity; >250 mgL⁻¹ where as in monsoon-2022 as min. 110.016 (BC₃) and max. 254.89 mgL⁻¹ (BC₇). There experimental values are under permissible unit as per BIS (2012)¹⁹ and WHO (2011)²⁰ standard drinking water.

DO :- Dissolve oxygen is essential parameter for aquatic life. It is determined in the winker Azide method as min. 147.8mgL⁻¹ (BC₅) and max. 181.1 mgL⁻¹ (BC₃) in Postmonsoon- 2021, as min 147.8 mgL⁻¹ (BC₈) and 181.1 mgL⁻¹ (BC₃), (147.8mgL⁻¹, (BC₈) and 181.8mgL⁻¹ (BC₂), premonsoon 2022 min. 173.8 mgL⁻¹ (BC₅) and max. 199.6 mgL⁻¹ (BC₁₀) and monsoon 2022 min 135.4 mgL⁻¹ (BC₁₀) and 242.6 mgL⁻¹ (BC₂). The finding results are much more high than the standard value; 5mgL⁻¹ BIS (2012)¹⁹ and WHO (2011)²⁰.

BOD :- The demanding parameter is require to oxygen by the microorganism for biological degradation of organic matter. In assessment of different season the finding results were reported as min. 2 mgL⁻¹ (BC₂) and max. 11 mgL⁻¹ (BC₅) min.9.4 mgL⁻¹ (BC₆) and 15mgL⁻¹(BC₄); min 2mgL⁻¹ (BC₄) and 9 mgL⁻¹ (BC₂) for postmonsoon 2021, premosoon 2022 and monsoon-2022 respectively. The max. observation result are above the excessive permissible limit as per BIS (2012) and WHO ¹⁹(2011) ²⁰orderly.

COD:- The amount of oxygen is require for the oxidation of the oxidisable organic matters reflex by the COD. The experimental value has processed in different session, post monsoon 2021 as min. 3 mgL⁻¹ (BC₃) and max 15 mgL⁻¹ (BC₁₀) while premonsoon 2022 the min 9.4 mgL⁻¹ (BC₆) and mix. 15mgL⁻¹ (BC₄) where as monsoon the min. value was reported as 3.00 mgL⁻¹ (BC₃) and max 8.00 mgL⁻¹ (BC₁₀) The most of the observation has recorded under permissible limit as per BIS (2012)¹⁹ and WHO (2011)²⁰.

Chloride:- The amount of chloride in high concentration is objectional test; salty fast; up to 200 mgL⁻¹ is not harmful for living organism. The finding result were seen as min. 259 mgL⁻¹ (BC₁) and max. 350 mgL⁻¹ (BC₄) for post monsoon-2021 and min. 299 mgL⁻¹ (BC₆) and 978 mgL⁻¹ (BC₃) and 340 mgL⁻¹ (BC₃) for monsoon. The high value of 978 mgL⁻¹ above dissolve of the chloride compound form domestic source.

Fluoride:- Fluoride compound is highly soluble in aquatic system from natural weathering of the rock and discharging of the effluent in water sources. The permissible limit of fluoride ion in water drinking is 1.00 mgL^{-1} to 1.50 mgL^{-1} . The observation value of fluoride ion concentration as min. BDL while max. 0.417 mgL^{-1} (BC_5) in post monsoon 2021 and for min. 0.092 mgL^{-1} (BC_4) and max. 2.715 mgL^{-1} (BC_{10}) in pre monsoon 2022 min. value as 0.102 mgL^{-1} (BC_3) and max. 5.178 mgL^{-1} (BC_8) was noted down for monsoon. The two max. conc. Was above the permissible value 1.5 mgL^{-1} as per BIS (2012)¹⁹ and WHO (2011)²⁰.

Sulphate :- The source of sulphate ion is surface water in domestic sewage and Industrial effluent. The detection value was recorded in three different season postmonsoon-2021 as min. 0.024 mgL^{-1} (BC_3) and max. 223.01 mgL^{-1} (BC_7) and for premonsoon-2022 as min. 1.59 mgL^{-1} (BC_2) and max 325.45 mgL^{-1} (BC_8) and for monsoon-2022 as min. BDL and max. 163.19 mgL^{-1} (BC_6) was recorded entire observation was under the permissible limit as per BIS (2012)¹⁹ and WHO (2011)²⁰ nature of drinking water standard.

Phosphate :- Phosphate present in water bodies in the form of organic and inorganic phosphate. In the study period the detection conc. was made for postmonsoon 2021 as min and max. BDL while premonsoon-2022 as min. 0.5 mgL^{-1} (BC_8) and max. 7.3 mgL^{-1} (BC_3) where as monsoon -2022 as min 0.10 mgL^{-1} (BC_7) and 1.121 mgL^{-1} (BC_9) was noted down. The max. value 7.3 mgL^{-1} was above the permissible limit as per BIS (2012)¹⁹ and WHO (2011)²⁰ standard.

Nitrate :- The source of nitrate conc. for surface water in domestic and industrial effluents the high conc. causes of blue-body disease in results. The observation value was seen as min. 12.16 mgL^{-1} (BC_3) and max 65.00 mgL^{-1} (BC_1) for postmonsoon-2021 and as min. 10.76 mgL^{-1} (BC_2) and max. 129 mgL^{-1} (BC_9) for premonsoon-2022. For monsoon the min. conc. was detected as BDL and max. was 100.647 mgL^{-1} (BC_3). The max. values above the permissible limit; 45 mgL^{-1} as per BIS (2012)¹⁹ and WHO (2011)²⁰ standard.

Sodium :- Sodium is alkaline light metallic elements, Its maximum compounds are dissolved in water. Surface water is contaminated by the domestic sewage while ground water associated with high conc. of Na by the weathers of rock salt. In our investigation period, the conc. of sodium was detected as min. 17.8 mgL^{-1} (BC_8) and max. conc. 71.5 mgL^{-1} (BC_6) in postmonsoon-2021, while in premonsoon-2022, the min. conc. 14.8 mgL^{-1} (BC_8) and max. 114 mgL^{-1} (BC_6) but in monsoon-2022, the low conc. was finding 11.0 mgL^{-1} (BC_7) and was seen as 28.8 mgL^{-1} (BC_5). The value of dissolved ions are observed under permissible limit.

Potassium :- Potassium is alkaline in nature, their compounds are dissolved in water. At are study period the potassium was observed as min. 3.39 mgL^{-1} (BC_8) and max. 21.5 mgL^{-1} (BC_7) in postmonsoon-2021, and low and high conc. of potassium was detected 3.50 mgL^{-1} (BC_8) and 19.4 mgL^{-1} (BC_9) in premonsoon-2022. The min and max. conc. was detected 2.40 mgL^{-1} (BC_2) and 5.60 mgL^{-1} (BC_{10}) in monsoon-2022. The high value was exceeded the permissible limit.

Heavy metal :- HM is a group of metal, which density is high than water, or 5 gram/L^{-1} . At the study of surface water, we have selected five heavy metals; As, Cr, Mg, Cd and Fe for determine the qualitative and quantitative point

of view in Arpa river water system. The low conc. of the As, Cr, Hg, Cd, and Fe in postmonsoon -2021 were find out BDL, 0.001 mgL⁻¹(BC₉) BDL, 0.005 (BC₅) and 0.005 mgL⁻¹(BC₇) while the high conc. of there selected HM'S were seen 0.202 mgL⁻¹(BC₄), 0.248 mgL⁻¹(BC₃) 0.202 mgL⁻¹(BC₆), 0.017 mgL⁻¹(BC₁) and 0.230 mgL⁻¹(BC₄). In premonsoon-2022 the above selected HM'S were detected as min. cac. 0.001 mgL⁻¹(BC₈), 0.001 mgL⁻¹(BC₈) 0.001 mgL⁻¹(BC₉) 0.004 mgL⁻¹ (BC₃), 0.005 mgL⁻¹(BC₈). Where as the high cac. was note down 0.605 mgL⁻¹(BC₃), 0.303 mgL⁻¹(BC₃) 0.243 mgL⁻¹ (BC₈) 0.1 mgL⁻¹ (BC₂) 0.306 mgL⁻¹ (BC₈). In monsoon-2022 entire there HM's were detected as low value BDL, BDL, BDL, BDL and 0.007 mgL⁻¹(BC₁₀) and high value 0.404,(BC₄), 0.1200 mgL⁻¹(BC₄), BDL, 0.013 mgL⁻¹(BC₁) and 0.318 mgL⁻¹(BC₁₀) were detected as high cac. All there observed value are below the threshold value prescribed by the BIS (2012)¹⁹ and WHO (2011)²⁰.

Table IIa = Postmonsoon correlation matrix

Correlation post monsoon 2021

	Temperature	pH	EC	TS	TDS	TSS	Turbidity	Total Hardness	Calcium	Magnesium	Nitrate	Sulphate	Chloride	Free chlorine	DO	M.V.	Salinity	Na	K	Hg	Cd	As	Cr	Fe	CO ₃	BDL
Temperature	1.0000																									
pH	0.6136	1.0000																								
EC	-0.1387	-0.3808	1.0000																							
TS	0.8232	0.6180	-0.7200	1.0000																						
TDS	0.8093	0.6790	-0.5100	0.9402	1.0000																					
TSS	-0.0547	-0.2729	0.1742	-0.2874	-0.0524	1.0000																				
Turbidity	-0.5380	-0.0311	0.4117	-0.5387	0.1288	-0.3628	1.0000																			
Total Hardness	0.3033	0.5762	-0.6300	0.5186	0.7038	-0.5972	0.0611	1.0000																		
Total alkalinity	-0.5812	-0.0041	0.3055	-0.5580	-0.0858	0.4908	0.0113	-0.7754	1.0000																	
Calcium	0.5478	0.2480	-0.0681	0.0517	0.2787	-0.3576	-0.3033	0.4729	-0.1531	1.0000																
Magnesium	-0.4620	-0.1251	0.1310	-0.3081	0.0281	-0.1508	0.4488	-0.4624	0.2887	-0.5788	1.0000															
Sulphate	0.0215	-0.0205	-0.6652	0.2053	0.2187	-0.2048	-0.2272	0.3861	-0.4388	0.0671	-0.2684	1.0000														
Fluoride	0.0112	0.1385	-0.3865	0.1077	0.2030	-0.2051	0.2775	0.1095	0.1114	-0.0277	-0.2604	-0.2581	1.0000													
Free chlorine	-0.2983	-0.0879	0.3583	-0.1072	0.0862	-0.1205	0.4865	0.0137	-0.3438	-0.4533	0.5220	-0.1878	-0.1737	1.0000												
DO	0.1157	0.2618	0.0884	-0.0209	0.0074	0.0214	0.4092	-0.0201	0.1545	-0.1301	-0.1104	-0.5758	0.0686	-0.0101	1.0000											
M.V.	0.0144	0.0382	-0.1047	0.0511	0.0209	-0.1242	0.6223	-0.7782	0.2007	-0.1721	0.3711	-0.1445	-0.1030	-0.2292	1.0000											
Salinity	0.5807	0.3465	0.1021	0.2304	-0.0209	0.1060	-0.2802	-0.1281	-0.1431	0.0604	-0.0301	-0.5651	-0.0501	0.1802	0.3701	0.1511	1.0000									
Na	0.5304	0.5174	-0.7111	0.6228	0.4664	-0.3725	-0.5029	0.3256	-0.5134	0.2007	-0.3878	0.3686	0.0603	0.0077	-0.0827	0.3460	0.3805	1.0000								
K	0.4290	0.0667	0.5716	0.0514	-0.1486	0.2423	0.0809	0.2385	-0.3021	0.1022	-0.1761	-0.2881	-0.1391	-0.0807	0.0201	0.4251	0.3471	-0.3502	1.0000							
Hg	0.4653	0.0033	-0.3469	0.6010	0.8615	-0.7123	0.0110	0.7024	-0.8005	0.1179	-0.0870	-0.0681	0.1202	0.2268	0.1121	0.7229	0.4241	0.1546	0.2361	1.0000						
Cd	0.1700	0.3727	-0.0271	0.1402	0.1547	-0.1883	0.0302	0.3454	-0.1888	0.3605	-0.0474	-0.1408	0.1361	0.0571	0.2603	0.5741	0.1520	0.1121	0.5713	1.0000						
As	0.0855	0.0403	0.2757	-0.0521	0.0158	-0.0489	-0.2726	-0.0124	0.2773	0.5649	0.0017	-0.0054	-0.4121	-0.4802	-0.2386	0.2332	-0.1213	-0.2251	0.3660	-0.0707	-0.1362	1.0000				
Cr	-0.3008	-0.0405	-0.1510	-0.3526	0.0547	-0.2580	0.0814	0.2346	-0.1600	0.5605	-0.3873	0.4102	0.0452	-0.0476	0.0179	-0.1067	-0.2288	0.3034	-0.4215	-0.1346	0.3853	-0.1031	1.0000			
Fe	-0.0078	0.1480	-0.1178	0.0973	0.1786	-0.4786	-0.2120	0.4305	-0.2286	0.7911	-0.2231	0.1607	-0.1646	-0.0134	-0.3463	0.1254	-0.1631	0.4136	-0.1780	0.1967	0.5508	0.1571	0.6889	1.0000		
CO ₃	0.2131	-0.1274	0.6322	-0.0205	-0.2068	0.1176	0.1586	0.0700	-0.1461	-0.1503	0.1146	-0.3531	-0.1461	0.1461	-0.0001	0.2171	0.1866	-0.0003	0.0939	0.1025	-0.0138	0.2671	-0.1558	-0.1339	1.0000	
BDL	0.0258	0.2980	0.2620	0.1589	0.1386	-0.0111	-0.3510	0.4242	-0.5403	0.2001	-0.1888	0.0101	-0.5121	-0.0871	-0.1081	0.6091	0.3101	-0.0121	0.8863	0.4726	0.2067	0.8540	-0.2011	0.0856	0.7864	1.0000

Table IIb – Premonsoon correlation matrix

Correlation pre monsoon 2022

	Temp	pH	EC	TS	TDS	TSS	Turbidity	Total Hardness	Total alkalinity	Chloride	Nitrate	Sulphate	Fluoride	Free chlorine	DO	M.V.	Salinity	Na	K	Hg	Cd	As	Cr	Fe	COO	BOD
Temperature	1.0000																									
pH	0.5030	1.0000																								
EC	-0.8808	-0.4557	1.0000																							
TS	0.8681	0.6157	-0.7142	1.0000																						
TDS	0.4094	0.5418	-0.5704	0.4227	1.0000																					
TSS	-0.1931	-0.4202	0.4163	-0.1621	-0.9609	1.0000																				
Turbidity	0.6630	0.6126	-0.5586	0.6102	0.1752	-0.0373	1.0000																			
Total Hardness	0.3591	-0.1552	-0.3204	0.2468	0.4853	-0.4337	-0.0701	1.0000																		
Total alkalinity	0.5876	0.3701	-0.4929	0.5690	0.4404	-0.2983	0.2694	0.6830	1.0000																	
Chloride	0.0879	0.3166	-0.1283	0.0035	0.3883	-0.4278	0.0684	0.4808	0.7301	1.0000																
Nitrate	-0.5048	-0.3240	0.4382	-0.3527	-0.4411	0.3627	-0.2613	-0.7020	-0.9329	-0.8135	1.0000															
Sulphate	0.2975	0.2134	-0.2598	0.4774	0.4433	-0.3571	0.4409	0.4881	0.3729	0.2416	-0.2357	1.0000														
Fluoride	0.3018	0.2058	-0.4401	0.2668	0.2162	-0.1180	-0.1294	-0.0100	0.2701	-0.0423	-0.2456	-0.5062	1.0000													
Free chlorine	-0.3612	-0.2830	0.3082	-0.2989	-0.2594	0.1864	-0.1656	-0.4636	-0.9039	-0.7839	0.8911	-0.1013	-0.3177	1.0000												
DO	0.0334	0.3014	0.0030	-0.0176	0.2789	-0.2763	-0.3527	-0.0342	0.0441	0.0443	-0.1452	-0.5986	0.6007	-0.0700	1.0000											
M.V.	-0.0914	0.0267	0.3004	0.1358	-0.1681	0.2313	0.1457	-0.3721	-0.4180	-0.6843	0.4919	0.0071	-0.0988	0.4181	0.0233	1.0000										
Salinity	-0.8665	-0.4401	0.9963	-0.7124	-0.5578	0.4043	-0.5567	-0.2907	-0.4795	-0.1035	0.4118	-0.2565	-0.4501	0.3141	0.0347	0.2680	1.0000									
Na	0.7223	0.7876	-0.6178	0.6885	0.5498	-0.4239	0.8519	0.0843	0.3474	0.1876	-0.3294	0.5026	-0.1282	-0.1823	-0.0649	0.1207	-0.6060	1.0000								
K	0.3805	0.2642	-0.3541	0.3368	0.3002	-0.2743	0.6089	0.2945	0.2408	0.3172	-0.2127	0.7974	-0.6594	-0.0481	-0.6263	-0.2405	-0.3382	0.6534	1.0000							
Hg	-0.0249	0.6925	0.1457	0.2169	0.4413	-0.4106	0.1102	0.0787	0.3732	0.5462	-0.3598	0.2770	-0.0812	-0.3940	0.3656	-0.0075	0.1783	0.3598	0.1240	1.0000						
Cd	-0.8822	-0.4313	0.8214	-0.8150	-0.3166	0.1010	-0.4581	-0.3970	-0.6813	-0.2430	0.5432	-0.2835	-0.3670	0.4362	-0.0066	0.4031	0.7978	-0.4758	-0.3257	-0.0337	1.0000					
As	-0.3373	-0.0013	0.3637	-0.0902	-0.1722	0.1554	-0.1888	0.0722	0.1858	0.4361	-0.0635	0.3604	-0.4001	-0.1211	-0.3138	0.3848	-0.2334	0.2702	0.4392	-0.0455	1.0000					
Cr	-0.3191	0.1373	0.2135	-0.5835	0.0452	-0.2393	-0.1419	-0.1463	-0.0648	0.5363	-0.2128	-0.4316	-0.0807	-0.1676	0.3624	-0.4688	0.2430	-0.0311	-0.0331	0.2724	0.3116	0.0345	1.0000			
Fe	0.3653	0.0384	-0.4580	-0.0726	0.2019	-0.2745	0.3792	0.3089	0.2648	0.4619	-0.4693	0.0720	-0.1734	-0.3164	-0.1967	-0.5556	-0.4406	0.3825	0.5332	-0.2363	-0.2484	-0.2447	0.5148	1.0000		
COO	-0.2463	-0.4598	0.5751	-0.0603	-0.3577	0.3950	-0.4248	0.2952	0.0000	-0.1756	0.1038	0.1446	-0.3600	0.1137	-0.0364	0.3231	0.5885	-0.3854	-0.1378	0.0801	0.1874	0.3263	-0.3847	-0.4946	1.0000	
BOD	0.1316	-0.0009	0.2137	0.2788	-0.0053	0.1016	0.1041	0.5547	0.4235	0.2596	-0.3592	0.5764	-0.4698	-0.1909	-0.1739	0.0916	0.2531	0.1418	0.3570	0.4305	-0.1771	0.4693	-0.2779	-0.1560	0.7456	1.0000

Table IIc = Monsoon correlation matrix

Correlation monsoon 2022

	Temp	pH	EC	TS	TDS	TSS	Turbidity	Total Hardness	Total alkalinity	Chloride	Nitrate	Sulphate	Fluoride	Free chlorine	DO	M.V.	Salinity	Na	K	Hg	Cd	As	Cr	Fe	COO	BOD
Temperature	1.0000																									
pH	0.5030	1.0000																								
EC	-0.8808	-0.4557	1.0000																							
TS	0.8681	0.6157	-0.7142	1.0000																						
TDS	0.4094	0.5418	-0.5704	0.4227	1.0000																					
TSS	-0.1931	-0.4202	0.4163	-0.1621	-0.9609	1.0000																				
Turbidity	0.6630	0.6126	-0.5586	0.6102	0.1752	-0.0373	1.0000																			
Total Hardness	0.3591	-0.1552	-0.3204	0.2468	0.4853	-0.4337	-0.0701	1.0000																		
Total alkalinity	0.5876	0.3701	-0.4929	0.5690	0.4404	-0.2983	0.2694	0.6830	1.0000																	
Chloride	0.0879	0.3166	-0.1283	0.0035	0.3883	-0.4278	0.0684	0.4808	0.7301	1.0000																
Nitrate	-0.5048	-0.3240	0.4382	-0.3527	-0.4411	0.3627	-0.2613	-0.7020	-0.9329	-0.8135	1.0000															
Sulphate	0.2975	0.2134	-0.2598	0.4774	0.4433	-0.3571	0.4409	0.4881	0.3729	0.2416	-0.2357	1.0000														
Fluoride	0.3018	0.2058	-0.4401	0.2668	0.2162	-0.1180	-0.1294	-0.0100	0.2701	-0.0423	-0.2456	-0.5062	1.0000													
Free chlorine	-0.3612	-0.2830	0.3082	-0.2989	-0.2594	0.1864	-0.1656	-0.4636	-0.9039	-0.7839	0.8911	-0.1013	-0.3177	1.0000												
DO	0.0334	0.3014	0.0030	-0.0176	0.2789	-0.2763	-0.3527	-0.0342	0.0441	0.0443	-0.1452	-0.5986	0.6007	-0.0700	1.0000											
M.V.	-0.0914	0.0267	0.3004	0.1358	-0.1681	0.2313	0.1457	-0.3721	-0.4180	-0.6843	0.4919	0.0071	-0.0988	0.4181	0.0233	1.0000										
Salinity	-0.8665	-0.4401	0.9963	-0.7124	-0.5578	0.4043	-0.5567	-0.2907	-0.4795	-0.1035	0.4118	-0.2565	-0.4501	0.3141	0.0347	0.2680	1.0000									
Na	0.7223	0.7876	-0.6178	0.6885	0.5498	-0.4239	0.8519	0.0843	0.3474	0.1876	-0.3294	0.5026	-0.1282	-0.1823	-0.0649	0.1207	-0.6060	1.0000								
K	0.3805	0.2642	-0.3541	0.3368	0.3002	-0.2743	0.6089	0.2945	0.2408	0.3172	-0.2127	0.7974	-0.6594	-0.0481	-0.6263	-0.2405	-0.3382	0.6534	1.0000							
Hg	-0.0249	0.6925	0.1457	0.2169	0.4413	-0.4106	0.1102	0.0787	0.3732	0.5462	-0.3598	0.2770	-0.0812	-0.3940	0.3656	-0.0075	0.1783	0.3598	0.1240	1.0000						
Cd	-0.8822	-0.4313	0.8214	-0.8150	-0.3166	0.1010	-0.4581	-0.3970	-0.6813	-0.2430	0.5432	-0.2835	-0.3670	0.4362	-0.0066	0.4031	0.7978	-0.4758	-0.3257	-0.0337	1.0000					
As	-0.3373	-0.0013	0.3637	-0.0902	-0.1722	0.1554	-0.1888	0.0722	0.1858	0.4361	-0.0635	0.3604	-0.4001	-0.1211	-0.3138	0.3848	-0.2334	0.2702	0.4392	-0.0455	1.0000					
Cr	-0.3191	0.1373	0.2135	-0.5835	0.0452	-0.2393	-0.1419	-0.1463	-0.0648	0.5363	-0.2128	-0.4316	-0.0807	-0.1676	0.3624	-0.4688	0.2430	-0.0311	-0.0331	0.2724	0.3116	0.0345	1.0000			
Fe	0.3653	0.0384	-0.4580	-0.0726	0.2019	-0.2745	0.3792	0.3089	0.2648	0.4619	-0.4693	0.0720	-0.1734	-0.3164	-0.1967	-0.5556	-0.4406	0.3825	0.5332	-0.2363	-0.2484	-0.2447	0.5148	1.0000		
COO	-0.2463	-0.4598	0.5751	-0.0603	-0.3577	0.3950	-0.4248	0.2952	0.0000	-0.1756	0.1038	0.1446	-0.3600	0.1137	-0.0364	0.3231	0.5885	-0.3854	-0.1378	0.0801	0.1874	0.3263	-0.3847	-0.4946	1.0000	
BOD	0.1316	-0.0009	0.2137	0.2788	-0.0053	0.1016	0.1041	0.5547	0.4235	0.2596	-0.3592	0.5764	-0.4698	-0.1909	-0.1739	0.0916	0.2531	0.1418	0.3570	0.4305	-0.1771	0.4693	-0.2779	-0.1560	0.7456	1.0000

Statistical parameters: Correlation matrix.

In postmonsoon- 2021 total (r) values were calculated 351; + ve = 204 and -ve = 147, In premonsoon - 2022; the total relations were completed 351; + ve were 189 while -ve were 162, where as in monsoon - 2022 the total finding results were 348 in which +ve were 188 and -ve value were found by the calculation 160. Stronge positive correlations were seen between Temp. vs TS (r = +0.8232), pH vs TDS (r = +0.8790), pH vs Hg (r = +0.9033), TDS vs Hg (r = +0.8415), whereas high degree negative correlation observed between TA vs Hg (r = -0.8005) and postmonsoon (2021), In pre-monsoon 2022 the strong correlations were remarked between Temp vs TDS (r = 0.8601) TDS vs TSS (r = 0.9609) Temp. vs Na (+0.8519), Nitrate vs Free chlorine (r = 0.8911) and negative correlation were established

between Temp. vs EC ($r = -0.8088$), Temp vs Cd ($r = 0.8822$), Tot Alk. Vs Nitrate ($r = 0.9329$) Total Alk. Vs Free chlorine ($r = 0.9039$) and monsoon 2022 Temp. Vs TS ($r = +0.8021$) and EC vs salinity ($r = 0.8169$). Negative correlation was noted down TA vs Salinity ($r = -0.8531$).

WQI:

Water quality index was mathematically calculated by the standard method. The finding results are ranged from 143.02 (BC_{10}) to 9820.44 (BC_7) in premonsoon (2022) and in monsoon the ranges were covered from 101.21 (BC_9) to 175.40 (BC_2) in postmonsoon (2021) the ranges were seen from 252.23 (BC_2) to 13693.98 (BC_{10}). The index water quality is very high which indicated the water systems are high degree polluted.

Conclusion :

We have concluded after the pre-monsoon, monsoon and postmonsoon assessment of Arpa river water and its tributary in the session of 2021- 2022. The water quality of the river water is not applicable due to the high conc. of Chloride, Potassium, Sodium, Iron, COD, Fluoride parameters owing to over burden cum discharging of domestic sewage in Arpa river water. Therefore the water of these selected spots are essential before the use for development purpose.

Acknowledgement :

The authors are grateful to The Director General, Chhattisgarh Council of Science and Technology (CCOST) Raipur (C.G.) for testing of the selected heavy metal by the instrumental method and I am also deeply thankful to providing Research facility to Principal, Govt Bilasa Girls P.G. College Bilaspur (C.G.). I am deeply obliged of Dr. S. K. Swain for the analysis of heavy metals by ICP-MS.

References :-

1. Prasad N.R. and Patil, J.M.; A study of physico-chemical parameters of Krishna River water particularly in western Maharashtra, Rasayan, J. Chem, Vol. (04), 943-958 (2008).
2. Joshi, D.M. et al.; Statistical Analysis of physico-chemical parameters of water of River Ganga in Haridwar District, Rasayan, J. Chem, 2(3), 579-587 (2009).
3. Tharanitharan, V. et al.; water Quality Evaluation of River Kaveri at Salem Division, Tamil-nadu, India, J. Chem. Sci. Rev. Lett. 2(7), 588-595 (2014).
4. Kadarshahib, R. et al.; Assessing of water Quality Pollution increases for Heavy metal contamination of Periyar River, Tamil-nadu, South-India, Chem. Sci. Rev. Lett., 4(13), 153-163 (2015)
5. Khan, E.A. et. al.; Eutrophication of Ecological vision, Bot. R.N. 71(4), 449-432 (2005)

6. Eliku, T. and Lata S., Spatial and Seasonal variations in physicochemical parameters and Heavy metals in Awadh River, Ethiopia, *Apple. water sci.*, 8(6), 1-13(2018).
7. Mishra, S and Kumar, A.; Estimation of physicochemical characteristics and associated water contamination risk in the Narmada river, India, *Environ. Eng. Res.*, Vol.26 , 1-11(2021).
8. Uzoekwe, S.A. and Achodume, A.C.; Pollution status and effect of crude oil and sillage in vahotas stream Ecosystem in Niger Delta, *J. Eco. Nat. Environ.* 3, 469-473(2011).
9. Edori, O.S. and Lyama, W.A.; status of heavy metals contamination in water from Edagheri Greek, Engenni, River state, South-South Nigeria, *Biomedical* ,29(03), 22482-22488(2020).
10. Vaishnav, M.M.. et. al.; premonsoon study of Water Quality status of Arpa river at Bilaspur(C.G.), India, *IJERMT* , 11(06), pp. 21-28(2024).
11. Vaishnav, M.M., et. al.; Study of seasonal variability of Ground Water Quality in Surguja District (C.G.), India, *Asian, J. Eviron. Ecology*, 23(12), 120-123(2024).
12. Mishra R., Singh P.K. and Vaishnav, M.M; Physico-Chemical Parameters of Kelo River Water, *Asian journal of Pharmaceutical Education and Research*, 13(3),pp.178-185 (2024).
13. Vaishnav, M.M. et. al.; Industrial Effluents and their impact on water Pollution- An overview, *EC Gen.*, 5 , 1203 (2024).
14. Vaishnav, M.M. et al.; Periodic Water Quality Monitoring of Ground Water sources in Jashapur District, Chhattisgarh, India, *J. Applicable Chem.*, (3),pp.668-185 (2018).
15. De, A.K.; *Environmental Chemistry*, New Age International (P) limited New Delhi (2001).
16. APHA AWWA, WPCF, *Standard Method for Examination of Water and Waste Water*, American Public Health Association, Washington, USA (2005)
17. Muniwaskam ,N.; *Physico-Chemical Examination of water sewage and industrial effluent*, Pragati Prakashan, Meerut (2002)
18. Trivedi, R.K. and Goel, P.K.; *Chemical and Biological methods for Water Pollution Studies*, Karod, Environmental Publications (1986)
19. BIS, *Indian standard Drinking Water Specification (first Revision) 15:10500*, Bureau of Indian standard, New Delhi (2012)
20. WHO, *Guideline for Drinking Water Quality, Vol.I*, World- Health Organization, Geneva, (2011).