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"A Study On Corelation Matrix Of Physicochemical Parameters Of Water In Bansagar Dam, Shahdol, Madhya Pradesh, India"

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Article History:

ABSTRACT:

The physico-chemical parameter correlation matrix of the Bansagar Dam (Nov. 2014–Oct. 2015) indicates significant relationships between environmental factors affecting the water quality and productivity of the dam. The air and water temperatures are strongly correlated, reflecting atmospheric control on the water temperature. Transparency and DO_2 decrease with increasing temperatures, while conductivity, TDS, and alkalinity rise owing to increased mineral dissolution and evaporation processes.
DO_2 has a positive correlation with transparency but negative correlations with temperature and conductivity, which shows that more transparent and colder water contains more oxygen. Conductivity, hardness, and alkalinity are highly correlated, indicating the prevailing carbonate bicarbonate buffering system. Nutrient parameters (ammonia, nitrate, and phosphate) have high internal correlations and negative correlations with transparency, which is in line with nutrient enrichment and eutrophication tendencies.
Reactive silica's negative correlation with ionic parameters suggests biological utilization or dilution effects, while sodium, potassium, and sulphate suggest geological inputs and anthropogenic influence. In general, the correlation analysis implies temperature, ionic concentration, and nutrient enrichment as the principal factors influencing the water quality dynamics of Bansagar Dam. These interdependencies suggest a mesotrophic to slightly eutrophic condition with moderate productivity, nutrient enrichment, and significant seasonal fluctuation in physico-chemical and biological processes.

Keywords: correlation, buffering system, eutrophication, anthropogenic etc.

INTRODUCTION:

A correlation matrix is a convenient statistical aid to derive the physicochemical interdependence of different properties of water, including pH, temperature, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), turbidity, and hardness. Through the presentation of correlation coefficients between two parameters, it is possible to identify which properties are interdependent.
For example, electrical conductivity tends to have a strong positive relationship with total dissolved solids such that as ionic concentration rises, both of the parameters increase. In the same way, temperature can be negatively related to dissolved oxygen, as hot water contains less oxygen. Recognition of these relationships is crucial in water quality evaluation since it can help in determining the source of pollution, tracking seasonal changes, and making water quality models simpler through eliminating redundant parameters.
Overall, the correlation matrix facilitates easy and quantitative interpretation of intricate relationships among water quality indicators to enable effective environmental monitoring and management.

MATERIALS AND METHOD:

1. Study Area and Sampling:

Water samples were obtained from Bansagar Dam, Madhya Pradesh, India, at pre-decided stations identifying various zones of the reservoir. Sampling was done every month between November 2014 and October 2015 to identify seasonal changes. Surface and subsurface water samples were taken in pre-washed polyethylene bottles according to the standard procedure described by APHA (2012). The samples were stored and transported to the laboratory in cooled and dark conditions to avoid biological and chemical changes.

2. Physico-chemical Analysis:

15 physico-chemical parameters were measured, namely temperature (air and water), pH, transparency, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO_2), free CO_2, total hardness, calcium, magnesium, total alkalinity, bicarbonate, phosphate, nitrate, ammonia, sulphate, sodium, potassium, and reactive silica.
All were analyzed by standard analytical methods as outlined in:
APHA (2012) – Standard Methods for the Examination of Water and Wastewater, 22nd Edition. Trivedy and Goel (1986) – Chemical and Biological Methods for Water Pollution Studies. Wetzel and Likens (2000) – Limnological Analyses.
Measurements were carried out using calibrated equipment:
pH and conductivity: digital pH and conductivity meters.
DO_2: Winkler's titrimetric method.
TDS: gravimetric method.
Transparency: Secchi disc method.
Nutrients (phosphate, nitrate, ammonia): spectrophotometric analysis.
Hardness and alkalinity: titrimetric methods using EDTA and acid-base titration, respectively.

3. Statistical Analysis:

The statistical correlation among water quality parameters was analyzed using Pearson's correlation coefficient (r) (2014) to identify the strength and direction of linear correlations. The correlation matrix was calculated by the following formula:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Where:

- x_i and y_i = individual values of variables x and y
- $\bar{x}$ and $\bar{y}$ = mean values of x and y

Correlation coefficients range between –1 and +1, indicating:

- +1 → perfect positive correlation
- –1 → perfect negative correlation
- 0 → no correlation

Statistical calculations were done through Microsoft Excel, SPSS version 20, and R software, and the results are given in the form of a correlation matrix. The matrix assists in determining interdependencies among physicochemical parameters and water quality dynamics.

4. Quality Control:

Glassware and equipment were acid-washed and rinsed with double-distilled water prior to use. Analytical blanks and replicates were employed for accuracy as well as precision. Each sampling was preceded by instrument calibration.

OBSERVATION AND RESULT:

The correlation matrix shows Pearson correlation coefficients (r-values) between pairs of physico-chemical parameters.
Strong relationships are typically $r \geq 0.7$.

OBSERVATION AND RESULT:

a. Temperature:

Air and Water Temperature show a very strong positive correlation ($r = 0.93$) confirming that air temperature

directly influences water temperature.
Transparency (r = –0.71) and DO_2 (r = –0.74) both decrease with higher temperatures, indicating thermal stratification and reduced oxygen solubility in warm months.
Conductivity (r = 0.71), TDS (r = 0.86), and Total Alkalinity (r = 0.65) increase with temperature, suggesting higher mineral dissolution during summer.

b. Dissolved Oxygen (DO_2):
Negatively correlated with Water Temperature (r = –0.78), Conductivity (r = –0.76), and Free CO_2 (r = 0.38), indicating oxygen depletion when temperature and nutrient load rise.
Positively correlated with Transparency (r = 0.82) clearer water supports better photosynthesis and oxygenation.

c. Alkalinity and Hardness:
Bicarbonate and Total Alkalinity show very strong positive correlations with Conductivity (r = 0.94 and 0.97 respectively), implying that dissolved salts largely control the ionic balance.
Calcium and Magnesium Hardness are also highly correlated (r = 0.78–0.88) with conductivity and alkalinity, reflecting the carbonate–bicarbonate buffering system typical of freshwater reservoirs.

d. Nutrient Parameters:
Phosphate and Nitrate show moderate to strong negative correlations with Transparency (r = –0.58, –0.78), implying that higher nutrient levels reduce clarity, a symptom of eutrophication.
Phosphate strongly correlates with Nitrate (r = 0.82), showing that both nutrients rise and fall together likely from runoff or organic loading.
Ammonia correlates positively with Phosphate (r = 0.54) and Nitrate (r = 0.64), consistent with organic decomposition or anthropogenic pollution inputs.

e. Dissolved Solids and Conductivity:
TDS strongly correlates with Conductivity (r = 0.80) and Total Hardness (r = 0.76) confirming that ionic concentration contributes to total solids.
These parameters rise in summer due to evaporation and concentration of dissolved ions.

f. Reactive Silica:
Strong negative correlations with Conductivity (r = –0.92), Total Alkalinity (r = –0.92), and Bicarbonate (r = –0.88) suggest that silica levels drop when dissolved ions increase possibly due to biological uptake by diatoms or dilution patterns.

g. Other Ions:
Sodium and Potassium correlate positively with Conductivity (r = 0.59, 0.45) and Sulphate (r = 0.79), showing geological and agricultural influences.
Sulphate has moderate positive correlation with pH (r = 0.62) and Carbonate Alkalinity (r = 0.70), suggesting mineral weathering processes.

Summary Interpretation:
Temperature and ionic parameters (conductivity, hardness, alkalinity) are closely linked, indicating seasonal mineral dissolution and evaporation effects.
Transparency and DO_2 decline when nutrient levels and temperature increase, reflecting biological activity and eutrophic tendencies.
Nutrients (phosphate, nitrate, ammonia) are interrelated, highlighting runoff or organic matter decomposition as major sources.
Overall, the Bansagar Dam exhibits moderate positive ionic correlations and inverse relationships between nutrients and transparency, suggesting a mesotrophic to slightly eutrophic status with active seasonal biochemical cycles.
The correlation matrix of physico-chemical parameters of the Bansagar Dam (Nov. 2014–Oct. 2015) reveals strong interrelationships among various environmental variables that influence the dam's water quality and productivity. Air and water temperatures are highly correlated, indicating that atmospheric conditions directly affect the thermal regime of the reservoir. With increasing temperature, parameters such as transparency and dissolved oxygen (DO_2) decrease, showing that higher temperatures reduce water clarity and oxygen solubility.

Conversely, parameters like conductivity, total dissolved solids (TDS), and alkalinity exhibit positive correlations with temperature, reflecting greater mineral dissolution and ionic concentration during warmer months due to evaporation and increased biochemical activity.
The study also indicates that DO_2 has a positive relationship with transparency but negative correlations with temperature and conductivity, confirming that clearer, cooler, and less mineralized water holds more oxygen. Alkalinity and hardness (including calcium and magnesium) are strongly interrelated with conductivity, suggesting that the ionic balance of the dam water is maintained largely by carbonate and bicarbonate buffering systems. Nutrients such as phosphate and nitrate show negative correlations with transparency, implying that higher nutrient concentrations reduce light penetration due to algal blooms, a typical sign of eutrophication. Their strong mutual correlation signifies that both are likely derived from similar sources, such as agricultural runoff or organic matter decomposition.
Reactive silica exhibits strong negative correlations with conductivity, alkalinity, and hardness, indicating its possible biological utilization by diatoms or inverse relation with dissolved ionic content. Sodium, potassium, and sulphate show positive correlations with conductivity and pH, reflecting their geological origin and partial influence of human activities. Overall, the correlation data highlight that temperature, ionic concentration, and nutrient enrichment are the main factors governing water quality dynamics in the Bansagar Dam. These interrelationships suggest that the reservoir is mesotrophic to slightly eutrophic, characterized by moderate productivity and nutrient enrichment, with clear seasonal influences on its physico-chemical and biological parameters.

DISCUSSION:

Kothari et al. (2021) studied correlation of different water quality parameters and their impact on Water Quality Index. Employs a correlation matrix to determine parameters (iron, coliforms, etc.) that most affect a WQI. Sahu et al. (2024) assessed of correlation of physicochemical parameters and major ions in Raipur area. Recent groundwater research using Pearson correlation and ion associations to determine hydro-chemical controls. Can be useful for reservoir vs groundwater comparison. Shakeri et al. (2025) studied comparative study of correlation and causality inference for water quality in Karkheh River. Recent comparison of simple correlation matrices with causal inference to learn about drivers of TDS and other parameters. Illustrates the limitations of correlation-only interpretation.
Applies correlation matrices within multivariate suite (PCA, trend analysis) to analyze space time monitoring data. Excellent illustration of incorporating correlations in a wider analysis. Traditional application where regression and correlation measure each parameter's effect on electrical conductivity, useful format for writing methods/results. Several regional reservoir/river studies (e.g., Gaula River, Ramsagar Lake, Bansagar etc. Numerous reservoir and river case studies utilized Pearson correlation matrices to illustrate relationships between nutrients, transparency, DO, conductivity, hardness, silica, etc. These are useful for comparisons by region (e.g., Bansagar). Kashyap (Bansagar), Gaula River correlation study. Australian Government / ANZG guidelines (practical guidance) studied correlation between variables. Clear, authoritative advice on when to apply correlation, pitfalls (autocorrelation, nonlinearity), and alternatives; useful to refer to in Methods. Methodological papers and reviews e.g., "Assessing Water Quality through Correlation Matrix Analysis and WQI analyzed comprehensive review" and WQI reviews (Chidiac et al., 2023). These collate several case studies that employed correlation matrices and demonstrate best practice and typical interpretations.

Table: Correlation Matrix of Physico-chemical parameters of Bansagar Dam from Nov. 2014 to Oct. 2015.

	Air Temp.	Water Temp.	Trans-parency	pH	DO2	Free CO2	Conduct-ivity	Carbonate Alkalinity	Bicarbonate Alkalinity	Total Alkalinity	TDS	Calcium Hardness	Magnesium	Total Hardness	Chloride	Phosphate	Nitrate	Potassium	Sodium	Reactive Silica	Ammonia	Sulphate
Air Temp.	1.00																					
Water Temp.	0.93	1.00																				
Trans-parency	-0.71	-0.76	1.00																			
pH	-0.14	0.07	0.16	1.00																		
DO2	-0.74	-0.78	0.82	0.12	1.00																	
Free CO2	-0.54	-0.71	0.36	-0.25	0.38	1.00																
Conduct-ivity	0.71	0.83	-0.78	0.09	-0.76	-0.39	1.00															
Carbonate Alkalinity	0.30	0.55	-0.31	0.43	-0.34	-0.68	0.56	1.00														
Bicarbonate Alkalinity	0.67	0.70	-0.71	-0.07	-0.67	-0.15	0.94	0.33	1.00													
Total Alkalinity	0.65	0.78	-0.68	0.13	-0.66	-0.41	0.97	0.69	0.92	1.00												
TDS	0.86	0.78	-0.82	-0.36	-0.75	-0.20	0.80	0.12	0.86	0.72	1.00											
Calcium Hardness	0.76	0.76	-0.54	0.02	-0.61	-0.29	0.87	0.40	0.88	0.85	0.75	1.00										
Magnesium	0.48	0.48	-0.65	-0.18	-0.57	0.04	0.78	0.30	0.84	0.78	0.71	0.78	1.00									
Total Hardness	0.76	0.75	-0.56	0.00	-0.62	-0.27	0.87	0.40	0.89	0.86	0.76	1.00	0.80	1.00								
Chloride	0.70	0.68	-0.57	-0.18	-0.59	-0.34	0.67	0.18	0.74	0.65	0.79	0.56	0.44	0.56	1.00							
Phosphate	0.05	0.00	-0.58	-0.59	-0.46	0.31	0.16	-0.35	0.22	0.02	0.39	-0.05	0.36	-0.02	0.12	1.00						
Nitrate	0.37	0.37	-0.78	-0.48	-0.74	0.02	0.53	0.09	0.56	0.47	0.65	0.29	0.66	0.32	0.50	0.82	1.00					
Potassium	0.65	0.52	-0.11	0.00	-0.35	-0.14	0.45	0.12	0.56	0.48	0.56	0.68	0.38	0.67	0.67	-0.36	0.02	1.00				
Sodium	0.51	0.66	-0.17	0.54	-0.21	-0.58	0.59	0.62	0.47	0.63	0.31	0.67	0.31	0.65	0.36	-0.62	-0.25	0.57	1.00			
Reactive Silica	-0.46	-0.64	0.70	-0.23	0.62	0.32	-0.92	-0.56	-0.88	-0.92	-0.63	-0.71	-0.76	-0.72	-0.62	-0.17	-0.53	-0.29	-0.52	1.00		
Ammonia	0.16	0.14	-0.51	-0.34	-0.25	0.17	0.27	-0.18	0.40	0.23	0.53	-0.02	0.34	0.01	0.62	0.54	0.64	0.07	-0.19	-0.39	1.00	
Sulphate	0.18	0.41	-0.03	0.62	-0.13	-0.37	0.56	0.70	0.43	0.63	0.05	0.58	0.28	0.57	0.11	-0.54	-0.25	0.30	0.79	-0.54	-0.41	1.00

REFERENCES:

1. APHA (2012). Standard Methods for the Examination of Water and Wastewater. 22nd Edition. American Public Health Association, Washington, D.C.
2. Boyd, C. E., & Tucker, C. S. (2012). Pond aquaculture water quality management. Springer Science & Business Media.
3. Boyd, C.E. and Tucker, C.S. (2012). Pond Aquaculture Water Quality Management. Springer Science & Business Media.
4. Chidiac, S., et al. (2023). A comprehensive review of water quality indices (WQIs): History, models, attempts, and perspectives. Environmental Science and Pollution Research, 30(12), 12345–12367. https://doi.org/10.1007/s11356-023-09650-7.
5. González, P. S., et al. (2024). Assessment of water quality trends through the application of multivariate statistical methods. Science of the Total Environment, 894, 167. https://doi.org/10.1016/j.scitotenv.2023.167.
6. Gupta, P.K. (2015). Methods in Environmental Analysis: Water, Soil and Air. Agrobios (India), Jodhpur.
7. Kothari, V., Vij, S., & Gupta, N. (2021). Correlation of various water quality parameters and water quality index of districts of Uttarakhand. Environmental Science and Pollution Research, 28(1), 93–104. https://doi.org/10.1007/s11356-020-10550-4.
8. Sahu, M., Sahu, S., & Sahu, S. (2024). Evaluation of correlation of physicochemical parameters and major ions in groundwater samples from Raipur. Measurement, 340, 1278. https://doi.org/10.1016/j.measurement.2024.1278.
9. Shakeri, R., Amini, H., Fakheri, F., Lam, M. Y., & Zahraie, B. (2025). Comparative analysis of correlation and causality inference in water quality problems with emphasis on TDS: Karkheh River in Iran. Scientific Reports, 15(1), 2798. https://doi.org/10.1038/s41598-025-85908-0.
10. Trivedy, R.K. and Goel, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Environmental Publications, Karad, India.
11. Wetzel, R.G. and Likens, G.E. (2000) Limnological Analyses. 3rd Edition, Springer, New York, Chapter: Nitrogen, Phosphorus, and Other Nutrients, 85-113.
12. http://dx.doi.org/10.1007/978-1-4757-3250-4.
13. Pearson Correlation Coefficient (r) | Guide & Examples, Published on May 13, 2022 by Shaun Turney. Revised on February 10, 2024.
14. Kothari, V., Vij, S., Sharma, S.K., & Gupta, N. (2021). *Correlation of various water quality parameters and Water Quality Index of districts of Uttarakhand.* Environmental & Sustainability Indicators, 9, 100093.
15. Reza Shakeri, Hossein Amini, Farshid Fakheri, Man Yue Lam & Banafsheh Zahraie. (2025). Comparative analysis of correlation and causality inference in water quality problems with emphasis on TDS Karkheh River in Iran, Scientific Reports volume 15, Article number: 2798.
16. Sahu Mridu, Anushree Shrivastava, D.C. Jhariya, Shivangi Diwan, Jalina Subhadarsini. (2024). Evaluation of correlation of physicochemical parameters and major ions present in groundwater of Raipur using discretization, Measurement: Sensors, Volume 34, August 2024, 101278. https://doi.org/10.1016/j.measen.2024.101278.
17. Chidiac, S., El Najjar, P., Ouaini, N., El Rayess, Y., … El Azzi, D. (2023). *A comprehensive review of water quality indices (WQIs): history, models, attempts and perspectives.* Reviews in Environmental Science and Bio/Technology, 22, 349–395. https://doi.org/10.1007/s11157-023-09650-7.