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CORRELATION BETWEEN DIFFERENT PHYSICOCHEMICAL PARAMETERS OF GROUND WATER AND SURFACE WATER IN KOTA REGION, RAJASTHAN, INDIA

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Abstract

Water is the most precious gift of nature. It is the most vital factor that determines the development of a nation. Present study focuses on the correlation amongst physicochemical parameters (pH, Turbidity, Alkalinity, Total Hardness, Total dissolved solids, Conductivity, Chloride, Sulfate, Fluoride content) of ground water and surface water in Kota City (Rajasthan, India). Interrelationship studies between different variables are very helpful tools in promoting research and opening new frontiers of knowledge. The study of correlation reduces the range of uncertainty associated with decision making for mitigating pollution level.

Figures:10 References:11 Table: 3

Key Words: Physicochemical parameters, Correlation, Ground water, Surface water.

Introduction

The availability of liquid water and to a lesser extent its gaseous and solid forms, on Earth are important for existence of life. The earth is located in the habitable zone of the Solar System. If it were slightly closer or farther from the sun, the conditions would have been adverse which may not support life on earth (5). The collective mass of water on, under and over the surface of planet is known as Hydrosphere. India is a country with diverse landforms. Every State holds a unique geographical feature. Rajasthan is located in the North West region of India and is considered as a dry state, as it lacks sufficient rainfall and water resources. Still the South Eastern part of Rajasthan is blessed with sufficient annual rainfall and natural water resources. Therefore this part of the state has great social, economical and political importance. Being highly populated these resources are under the threat of overexploitation. Groundwater, rivers and ponds in Kota have provided livelihood to millions of people over the century. Owing to the human activities the water in these resources is getting polluted. With the increase on population the requirement for clean water increases constantly. The collection and disposal of domestic wastes is a major problem in urbanized area. The intensive use of natural resources and large production of waste in modern society often pose threat to ground and surface water quality (4). Water from most of the resources is therefore unfit for immediate consumption without some sort of treatment. The selected sites for the

present study, Kishore Sagar Talab, Chambal River, Kala Talab and Anantpura Talab cover almost every direction of Kota City area.

Materials and Methods

The present study was undertaken to determine the correlation amongst the various physicochemical parameters of water of the selected sample collecting sites of the surface water and ground water in Kota city (Rajasthan) and to evaluate the potability of surface water and ground water in the vicinity. For surface water analysis the water was sampled at the following points-

i) Kishore Sagar Talab (lake water)
ii) Chambal River (river water)
iii) Kala Talab (lake water)
iv) Anantpura Talab (pond water)

The water samples were collected in November 2017 between 7:00 am to 9:00 am so as to obtain the least disturbed samples. The physicochemical parameters (TDS, TSS, pH, electrical conductivity, turbidity, total hardness, total alkalinity, etc.) were analyzed for the water samples. Procedure outlined by APHA 1992 (Standard Methods for the Examination of water and Waste water) was followed.

The ground water samples were collected and analyzed in areas lying within 1-2 km radius of respective sampling sites. Total four areas were chosen for the sample collection. Water quality parameters were selected, which are considered to be important as per the drinking water standard (3, 6, 9).

After obtaining the readings of selected parameters for the analysis from the laboratory, the data was tabulated for comparative study. Simple linear correlation was calculated between the two tested parameters by using Pearson correlation equation.

$$r = \frac{N\sum(XiY_i) - (\sum X_i).(\sum Y_i)}{\sqrt{[N\sum X_i^2 - (\sum Xi)^2][N\sum Y_i^2 - (\sum Yi)^2)]}}$$

Where X_i and Y_i represents two different parameters and N is number of total observations.

Result and Discussion

The coefficient value can range between -1.00 to 1.00. If the coefficient value is in the negative range, then that means the relationship between the variables is negatively correlated, or as one value increases, the other decreases. If the value is in the positive range, then that means the relationship between the variables is positively correlated, or both the values increase or decrease together (11).

The correlation co-efficient (r) among various water quality parameters of ground water and surface water of selected sites in Kota Region of Rajasthan (India) are tabulated in table 2 and table 3 respectively.

Table 1. Physiochemical parameters of surface and ground water in Kota Region (Rajasthan)

S.No.	Parameter	Indian Standard	WHO Standard	Surface Water				Ground Water			
				Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV
I	pH	6.5 – 8.5	7 – 8	7.6	7.5	7.8	6.6	6.7	6.6	6.9	6.7
2	Conductance		300 µmho/cm	317	315	1068	767	917	495	1197	774
3	Turbidity	5 – 10	5	1.2	1.5	5.3	12.6	8.2	3.4	0.9	14.1
4	Total solids	500–2000	500	247	246	833	598	715	386	934	604
5	Total Hardness	187 – 500	(Calcium) 100	80	90	130	130	180	110	170	130
			(Magnesium) 100	70	40	130	140	200	60	270	160
6	Total Alkalinity	200 – 600	100-200	110	110	530	270	540	210	530	280
7	Cl^-	250–1000	250	20	30	120	110	40	60	150	110
8	SO_4	200 – 400	250	4	2	7	6	5	2	8	6
9	F	1 – 1.5	1	0.30	0.26	0.33	0.34	0.33	0.37	0.22	0.33

(Except pH and conductivity all results are in mg/l.)

Table 2. Correlation matrix for physicochemical parameters of ground water of selected sites in Kota Region of Rajasthan, India.

	pH	Turb.	Alkal.	Ca H	Mg H	Cl^-	SO_4	F^-	TDS	EC
pH	**1**	**-0.37567**	**0.717219**	**0.661457**	**0.928811**	**0.800071**	**0.927173**	**-0.9962**	**0.954245**	**0.953968**
Turb.		**1**	**-0.27216**	**-0.15174**	**-0.16039**	**-0.20305**	**-0.00115**	**0.446497**	**-0.25527**	**-0.25543**
Alkal.			**1**	**0.991635**	**0.881387**	**0.16196**	**0.667051**	**-0.68759**	**0.877459**	**0.878004**
Ca H				**1**	**0.865625**	**0.101566**	**0.655763**	**-0.62189**	**0.848922**	**0.849501**
Mg H					**1**	**0.581603**	**0.938784**	**-0.89736**	**0.99492**	**0.994934**

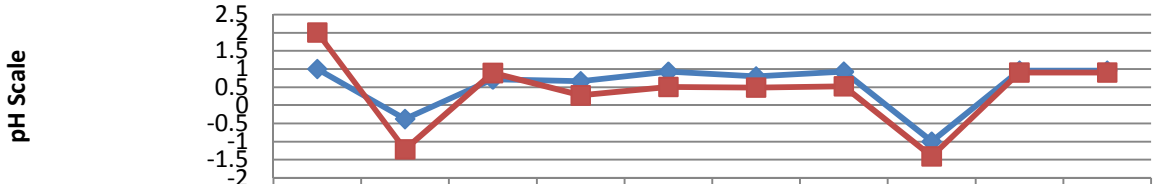
Cl^-						**1**	**0.778541**	**-0.81182**	**0.611282**	**0.6104**
SO_4							**1**	**-0.89426**	**0.927729**	**0.927369**
F^-								**1**	**-0.93113**	**-0.93083**
TDS									**1**	**0.999999**
EC										**1**

Table 3. Correlation matrix for physicochemical parameters of surface water of the selected sites in Kota Region of Rajasthan, India.

	pH	Turb.	Alkal.	Ca H	Mg H	Cl^-	SO_4	F^-	TS	EC
pH	**1**	**-0.83393**	**0.172413**	**-0.3875**	**-0.425**	**-0.31189**	**-0.14849**	**-0.40571**	**-0.05043**	**-0.05078**
TURB		**1**	**0.397729**	**0.820574**	**0.838408**	**0.779898**	**0.64176**	**0.784019**	**0.59191**	**0.59222**
Alkal.			**1**	**0.834343**	**0.767826**	**0.881225**	**0.868266**	**0.685401**	**0.974903**	**0.97481**
Ca H				**1**	**0.91177**	**0.993958**	**0.843115**	**0.802299**	**0.930938**	**0.930948**
Mg H					**1**	**0.930608**	**0.956047**	**0.976632**	**0.879725**	**0.880091**
Cl^-						**1**	**0.891372**	**0.833787**	**0.962787**	**0.962829**
SO_4							**1**	**0.951589**	**0.92101**	**0.921354**
F^-								**1**	**0.795522**	**0.796047**
TS									**1**	**1**
EC										**1**

pH – pH is negative logarithm of H+ ion concentration. pH of water ranges from 0 to 14. pH shows the acidic or alkaline nature of water (2). pH value from 7 to 14 is alkaline, pH value 0 to 7 is acidic and pH 7 is neutral. pH shows negative correlation with turbidity and fluoride and positive correlation with alkalinity in both ground water and surface water (fig.1).

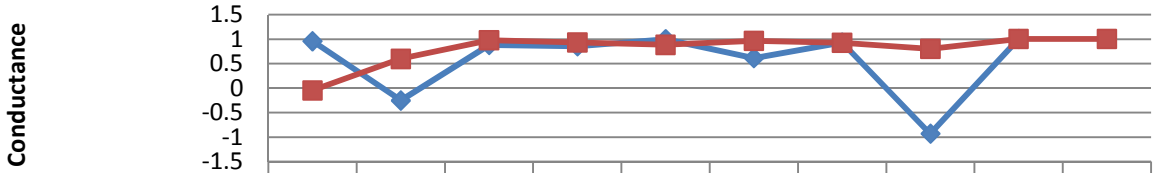
Figure 1. Correlation mtarix for pH



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	sulfate	Fluoride	TS	EC
pH surface water	1	-0.833	0.1724	-0.387	-0.425	-0.311	-0.405	-0.405	-0.050	-0.050
pH ground water	1	-0.375	0.7172	0.6614	0.9288	0.8000	0.9271	-0.996	0.9542	0.9539

Conductance – Conductance is the measure of water's capacity to pass electric flow (10). Conductance shows highest positive correlation with total solids in the water (fig. 2).

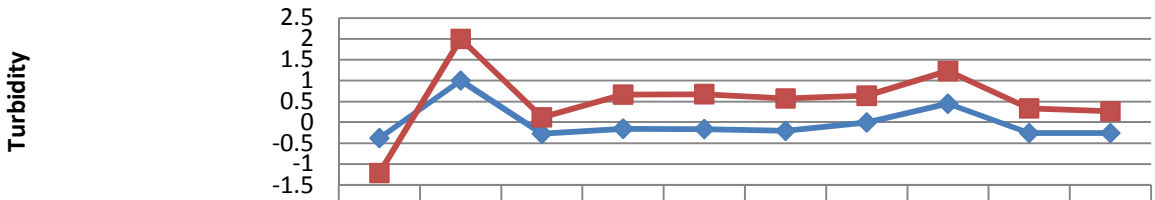
Figure 2. Correlation matrix for Conductance



	pH	Turbidity	Alkalinity	Ca Hardness	Mg Hardness	Chloride	Sulfate	Fluoride	TDS	EC
EC Ground water	0.9539	-0.255	0.878	0.8495	0.9949	0.6104	0.9273	-0.930	0.9999	
EC Surface water	-0.050	0.5922	0.9748	0.9309	0.8800	0.9628	0.9213	0.7960	1	1

Turbidity – Turbidity is the cloudiness of the fluid caused by large numbers of individual particles that are generally invisible to naked eyes, similar to smoke in air (1). Turbidity shows negative correlation with pH and positive correlation with fluoride in both surface water and ground water (fig. 3).

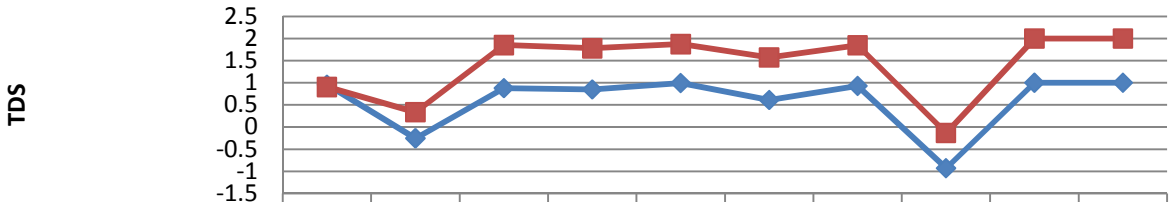
Figure 3. Correlation matrix for Turbidity



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Turbidity Surface water	-0.833	1	0.3977	0.8205	0.8384	0.7799	0.6417	0.7840	0.5919	0.5222
Turbidity Ground water	-0.375	1	-0.272	-0.151	-0.160	-0.203	-0.001	0.4465	-0.255	-0.255

Total Solids – Total Dissolved Solids and Total Suspended Solids together constitute the Total Solids in water (9). It is an important parameter which imparts a peculiar taste to water and reduce its potability. Total solids show high positive correlation with Chloride, Sulfate and Calcium / Magnesium hardness (fig. 4)

Figure 4. Correlation matrix for TS

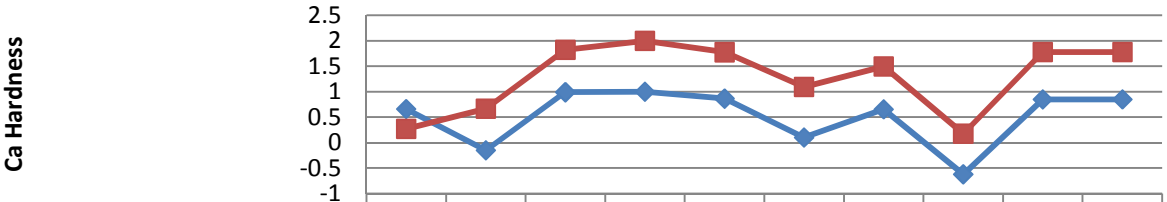


	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
TDS Surface water	-0.050	0.5919	0.9749	0.9309	0.8797	0.9627	0.9210	0.7955	1	1
TDS Ground water	0.9542	-0.255	0.8774	0.8489	0.9949	0.6112	0.9277	-0.931	1	1

Total Hardness – Total Hardness is measure of Poly valent cations in water. It generally represents the concentration of Calcium and Magnesium ions although other cations like aluminium, barium, iron, manganese etc. also contribute to it. Hardness affects the amount of soap that is needed to produce foam or lather. Hard water can also leave a film on hair, fabrics and glassware (9). Both Calcium and Magnesium hardness exhibits positive correlation with almost every physicochemical parameter (fig 5, 6).

Calcium Hardness

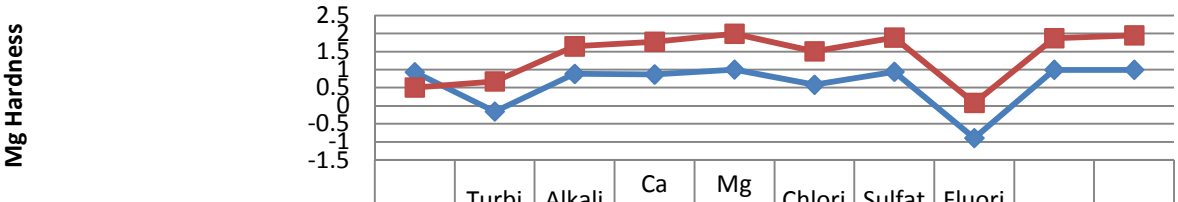
Figure 5. Correlation matrix for Ca Hardness



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Ca hardness surface water	-0.387	0.8205	0.8343	1	0.9117	0.9939	0.8431	0.8023	0.9309	0.9309
Ca hardness ground water	0.6614	-0.151	0.9916	1	0.8656	0.1015	0.6557	-0.621	0.8489	0.8495

Magnesium Hardness

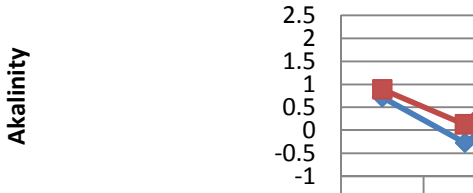
Figure 6. Correlation matrix for Mg Hardness



	pH	Turbidity	Alkalinity	Ca Hardness	Mg Hardness	Chloride	Sulfate	Fluoride	TS	EC
Mg hardness surface water	-0.425	0.8384	0.7678	0.9117	1	0.9306	0.9560	0.9766	0.8797	0.9628
Mg hardness ground water	0.9288	-0.160	0.8813	0.8656	1	0.5816	0.9387	-0.897	0.9949	0.9949

Total Alkalinity – Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Alkalinity not only helps regulate the pH of a water body, but also the metal content. Bicarbonate and Carbonate ions in water can remove toxic metals (such as lead, arsenic and cadmium) by removing the metal out of solution (9). Alkalinity is positively related to almost every physicochemical parameter (fig.7) Alkalinity was analyzed in surface and ground water at all four selected sites.

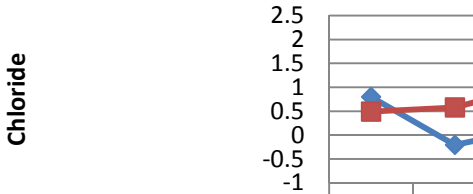
Figure 7. Correlation matrix for Alkalinity



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Alkalinity Surface water	0.1724	0.3977	1	0.8834	0.7678	0.8812	0.8682	0.6854	0.9749	0.9748
Alkalinity Ground water	0.7172	-0.272	1	0.9916	0.8813	0.1619	0.6670	-0.687	0.8774	0.878

Chloride – Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water. In fresh water, sources include soil and rock formation, sea spray and waste discharges. Sewage contains large amount of chloride, as do some industrial waste. Chloride does not pose a health hazard to human (5). Chloride is an important quality parameter that affects the aesthetic property of water including taste and renders it unsuitable for drinking purpose if present in high concentration (6). Following figure 8 expresses the correlation of Chloride content in water with other physicochemical parameters.

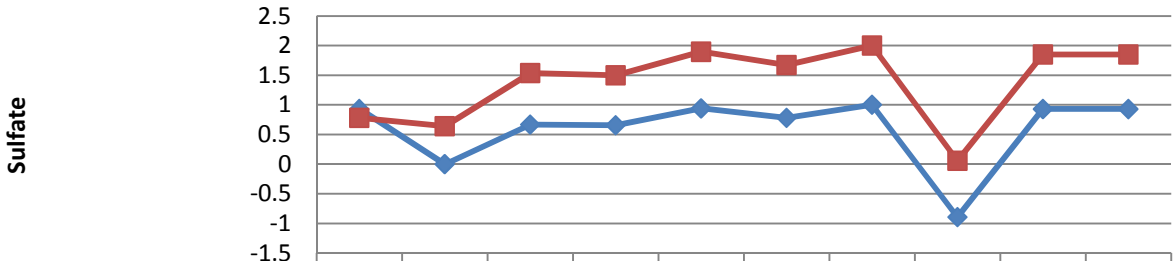
Figure 8. Correlation matrix for Chloride



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Chloride surface water	-0.311	0.7799	0.8812	0.9939	0.9306	1	0.8913	0.8337	0.9627	0.9628
Chloride ground water	0.8000	-0.203	0.1619	0.1015	0.5816	1	0.7785	-0.811	0.9277	0.9273

Sulfate – Sulfate is a substance that occurs naturally in drinking water at various concentrations (10). The sources of sulfate in underground waters may be rocks, geological formation and so on. Excess sulfate has a laxative effect, especially in combination with magnesium or sodium. Sulfate has high positive correlation with Total solids and conductivity (fig. 9).

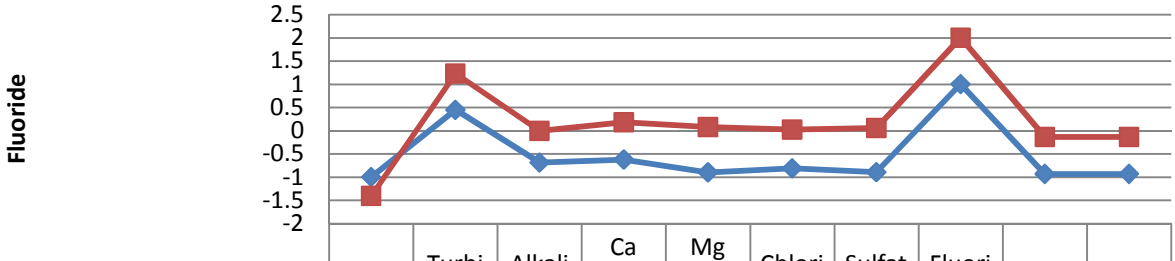
Figure 9. Correlation matrix for Sulfate



	pH	Turbidity	Akalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Sulfate Surface water	-0.148	0.6417	0.8682	0.8431	0.9560	0.8913	1	0.9515	0.9210	0.9213
Sulfate Ground water	0.9271	-0.001	0.6670	0.6557	0.9387	0.7785	1	-0.894	0.9277	0.9273

Fluoride – Water Fluoridation is the controlled addition of Fluoride in water supplies to maintain public health. Fluoridated water contains fluoride at a level that is effective for preventing cavities, this can occur naturally or by adding fluoride (pizzo et al). As per present study fluoride is negatively correlated to pH in both surface water and ground water (fig.10).

Figure 10. Correlation matrix for Fluoride



	pH	Turbidity	Alkalinity	Ca hardness	Mg hardness	Chloride	Sulfate	Fluoride	TS	EC
Fluoride Surface water	-0.405	0.7840	0.6854	0.8023	0.9766	0.8337	0.9515	1	0.7955	0.7960
FluorideGround water	-0.996	0.4465	-0.687	-0.621	-0.897	-0.811	-0.894	1	-0.931	-0.930

Summary and Conclusion

In the present study, Pearson's formula is used to derive the correlation between the two tested parameters. This analysis gives an idea of pollution in water resource. The study of correlation reduces the range of uncertainty associated with decision making for mitigating pollution level (8). The study will be helpful in sustainable development of the water resources in Kota city (Rajasthan).

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