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Temporal Assessment of Water Quality of River Jhelum Using Parametric and Non-Parametric Methods

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***Abstract*:** *Being the life line of the valley of Kashmir, the water quality of River Jhelum has a direct bearing on the sustenance of flora and fauna of the valley. This paper deals with a trend analysis of fourteen water quality parameters monitored at three stations located along River Jhelum from the year 2001 to 2012 by CWC (Central Water Commission, India). The analysis is performed on seasonal and annual timescales using both parametric and non-parametric methods – Mann-Kendall test and linear regression respectively. Also, this study highlights the advantages of non-parametric methods over parametric methods for studying water quality data that is not normally distributed.The results indicate an increase in the concentrations of water quality parameters of the River during the study period. The increase can be attributed to the continuing loading of the river with pollutants and to the lack of an appropriate management plan.*
Keywords *-Linear regression, Mann-Kendall test, River Jhelum, water quality parameters.*

I. INTRODUCTION

In recent years, an increasing awareness has been expressed in many countries about the impact of human activities on water resources and the adequacy of the quantity and quality of water for meeting human livelihood, wellbeing, and to assess environmental goals. One major goal of surface water quality data collection is the estimation of the magnitude of changes in the concentration of various constituents. The motivation of such estimates generally is to determine water quality impacts over time due to human activities, changes brought about by regulations, improvements to waste water treatment facilities, or land use changes. However, the surface waterquality may also be dependent on natural processes such as bio-geo-chemical environment and hydro meteorological climate of the river basin. Some of the necessities of water quality monitoring are:

1.To provide a system wide synopsis of water quality.
2.To monitor long-range trends in selected water quality parameters.
3.To detect actual or potential water quality problems, if such problems exist (3a) to determine specific causes and (3b) to assess the effect of any convective action.
4. To enforce standards. [1]

Trend analysis of water quality parameters has received considerable attention world over in the recent times.This may be attributed to the fact that deteriorating water quality is now a global problem. A brief account of recent research related to such analysis is presented here: Tsanis and El-Shaarawi [2] monitored and analyzed physical and chemical (nutrients and major ions) indicators of water quality in the Niagara and the St. Lawrence Rivers between 1977 and 1987. Evans and Jenkins[3]analyzed data for eight reservoirs in the South Pennines covering the periods 1980– 1998 and 1988–1998 at the River Etherow Acid Waters Monitoring Network site, for temporal trends using the Seasonal Kendall test. Raike et al [4]carried out a study to detect trend in nutrient data monitored in rivers and lakes in Finland between 1975 and 2000. The objective of their study was to investigate if the water protection measures that were in place had decreased nutrient and chlorophyll a concentrations in the rivers. Using the Seasonal Kendall test for trend analysis, they found that there were increasing trends in nutrients in rivers passing through Agricultural areas, while a decline in chlorophyll a was observed in a few places. Naddafi et al [5]monitored monthly measurements of the discharge and the water quality parameters at Gatvand and Khorramshahr stations of KaroonRiver for Gatvand and Khorramshahr stations respectively. They found positive trends for the majority of water quality parameters.Kannel[6] assessed variation of water qualities along the Bagmati River and its tributaries in the Kathmandu valley of Nepal during 1999–2003. Chang [7] examined water quality trends in the Han River basin of South Korea for eight parameters during 1993–2002. Bouza-Deano et al. [8] analyzed 34 physical–chemical and chemical variables in surface water samples collected every month in the Spanish Ebro River over a period of 24 years. Long term variation in water quality parameters in the Maroon River, Iran was carried out by HosseinTabari, Safar Marofi, MohammadAhmadi [9].The trend analysis was performed on seasonal and annual timescales using the Mann–Kendall test, the Sen's slope estimator and the linear regression. The relationships of the water quality parameters to river discharge were also investigated.
Water quality variables frequently exhibit variability in time. This variability may be cyclical with the seasons, steadily (a trend), abruptly (a step-change) or some other established variation over time. In this study, water

quality data collected by Central Water Commission (India)over a period of 10 years (2003– 2012) from three stations located along the Jhelum Riverwas used to test for the existence of annual and seasonal trends in water quality parameters. Two statistical methods, one parametric and one non-parametric – Mann-Kendall test and the Linear Regression respectively, were applied in this evaluation.The aim of the study was to estimate the magnitude of changes in the concentration of various constituents with time so as to ascertain any potential water quality problems. In fact, an increase in the concentrations of Water quality parameters of the river was revealed by the obtained results. The results of this study can be helpful in chalking out an effective management plan for the said river.

II. STUDY AREA AND DATA AVAILABILITY

The Jhelum is a large eastern tributary of the Indus. It drains areas west of the Pir Panjal range that separates Jammu and Kashmir. The Jhelum rises from the spring of Verinag, on the northwestern side of Pir Panjal and flows in a direction parallel to the Indus at an average elevation of 5,500 feet. It drains about 2,300 square miles of alluvial lands in Kashmir Valley and gets water from various important sources including glaciers located in the north of the valley. The present study describes the application of the Mann-Kendall test and linear regression to monitor the trends in water quality parameters at the following three sites located along River Jhelum (Fig. 1), India.

1. Sangam (33º49’21”N , 75º4’32”E)
2. Ram munshibagh (34º4’20”N , 74º49’59”E)
3. Saffapora (34º15’32”N , 74º39’42”E)

Water quality parameters were measured on monthly time-scale at these three stations of the river by CWC (Central Water Commission, India).As such, data collected from 2003 to 2012 by CWCwas used in this study.

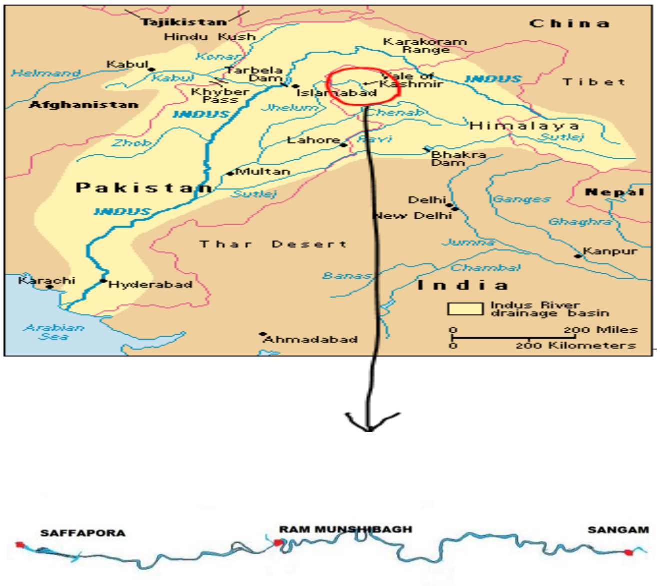

Fig. 1: Map showing sampling sites of River Jehlum

III. METHODOLOGY: PARAMETRIC AND NON-PARAMETRIC METHODS

Statistical methods that use distributional assumptions in analysis are called parametric methods. They are used with the assumption that the data under study is normally distributed. On the other hand, methods that do not require us to make such assumptions are called non-parametric methods. They don’t require the data to follow a particular distribution. In this study, both methods have been used. A description is given below:

3.1Mann–Kendall test

The Mann–Kendall test is a non-parametric test for identifying trends in timeseries data. The test compares the relative magnitudesof sample data rather than the data valuesthemselves [10]. One advantage of thistest is that the data need not conform to anyparticular distribution. The second advantage ofthe test is its low sensitivity to abrupt breaks dueto inhomogeneous time series. Accordingto this test, the null hypothesis H_0 statesthat the deseasonalized data $(x_1, . . . , x_n)$ is a sampleof n independent and identically distributed randomvariables. The alternative hypothesis H_1 ofa two-sided test is that the distributions of $x_k$and$x_j$are not identical for all k, $j \le n$ with $k \neq j$. Thestatistic S is defined as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn\left(x_j - x_k\right) \quad (1)$$

$$sgn\left(x_j - x_k\right) = \begin{cases} +1 \text{ if } \left(x_j - x_k\right) > 0 \\ 0 \text{ if } \left(x_j - x_k\right) = 0 \\ -1 \text{ if } \left(x_j - x_k\right) < 0 \end{cases} \quad (2)$$

$$\text{Var}\,(S) = \frac{\left[n\,(n-1)\,(2n+5) - \sum_t t\,(t-1)\,(2t+5)\right]}{18} \quad (3)$$

The notation t is the extent of any given tie and $\sum_t$ denotes the summation over all ties. In cases where the sample size n >10, the standard normal variable Z is computed by using the following equation:

$$Z = \begin{cases} \dfrac{S-1}{Var(S)^{1/2}} & \text{if S} > 0 \\ 0 & \text{if S} = 0 \\ \dfrac{S+1}{Var(S)^{1/2}} & \text{if S} < 0 \end{cases} \quad (4)$$

Positive values of Z indicate increasing trends while negative values of Z show decreasing trends. When testing either increasing or decreasing monotonic trends at a αsignificance level, the null hypothesis was rejected for absolute value of Z greater than $Z_{1-\alpha/2}$, obtained from the standard normal cumulative distribution tables [11]. In this research, significance levels of α = 0.01 and 0.05 were applied.

3.2Linear regression method

Simple linear regressionis an important and commonly used parametricmethod for identifying monotonic trend ina time series. It is used to describe the relationship between one variable with another or other variables of interest. It is often performed to obtain the slope of hydrological and meteorological variables on time. The model is formulated as follows:

$$Y = a + bT + \varepsilon_T$$

Where "*a*" is the intercept, "*b*" is the slope and " ε_T" represents random errors. T represents the year with the initial year taken as year 1. The errors are assumed to be independent and identically distributed. This assumption is more likely to be satisfied if yearly average is used as the response variable. Positive slope shows increasing trend while negative slope indicates decreasing trend [9]. Regressionhas the advantage that it provides a measure ofsignificance based on the hypothesis test on theslope and also gives the magnitude of the rateof change. The total change during the period under observation is obtained by multiplying the slope with the number of years.

IV. RESULTS AND DISCUSSIONS

4.1 Annual trends

Results of the linear regression (parametric method) and Mann–Kendall test (non-parametric method) on annual water quality parameters are presented in Table 1 and Table 2.Both positive and negative trends were identified by the tests in annual water quality data.

Table 1:Parametric Method

Parameters/Station			Sangam		Ram Munshi Bagh		Saffapora	
S. No	Parameter	Units	R^2	Slope	R^2	Slope	R^2	Slope
1	Ph		0.002	2.00E-05	0.08	O	8.00E-05	-4.00E-06
2	EC	uMho/cm	0.084	0.013	0.114	0.025	0.073	0.026
3	Calcium	mg/l	0.124	0.002	0.226	0.003	0.166	0.002
4	Magnesium	mg/l	0.017	0	0.021	0	0.055	0.001
5	Chloride	mg/l	0.306	0.001	0.355	0.001	0.166	0.001
6	Carbonate	mg/l	0.076	0.007	0.123	0.008	0.012	0.002
7	Sodium	mg/l	0.208	0.002	0.505	0.001	0.354	0.001
8	Potassium	mg/l	0.00005	-3.00E-06	0.034	-8.00E-05	0.001	4.00E-05
9	Total-P	mg/l	0.092	1.00E-05	0.362	3.00E-05	0.055	1.00E-05
10	Sulphate	mg/l	0.091	0	0.05	0	0.204	0.001
11	Turbidity	NTU	0.058	-3.00E-05	0.158	6.00E-05	0.065	3.00E-05
12	BOD	mg/l	0.133	O	0.021	-4.00E-05	0.002	-2.00E-05
13	COD	mg/l	0.118	4.00E-03	0.002	O	0.007	-1.00E-03
14	Do	NTU	0.07	O	0.04	O	0.116	0.00E+00

Table 2: Non-Parametric method

Parameters/Station			Sangam		Ram Munshibagh		Saffapora	
S.No	Parameter	Units	Kendall's Tau	Z	Kendall's Tau	Z	Kendall's Tau	Z
1	Ph		0.08	1.261	0.196	3.102	-0.02	-0.3
2	EC	uMho/cm	0.206	3.323	0.221	3.575	0.158	2.54
3	Calcium	mg/l	0.214	3.367	0.344	5.466	0.277	4.39
4	Magnesium	mg/l	0.038	0.604	0.088	1.425	0.172	2.77
5	Chloride	mg/l	0.44	7.069	0.486	7.832	0.291	4.68
6	Carbonate	mg/l	0.197	3.159	0.27	4.341	0.063	1.01
7	Sodium	mg/l	0.357	5.726	0.555	8.916	0.478	7.68
8	Potassium	mg/l	0.013	0.197	-0.146	-2.281	-0.083	-1.3
9	Total-P	mg/l	0.162	2.605	0.458	7.386	0.109	1.76
10	Sulphate	mg/l	-0.169	-2.69	-0.033	-0.52	-0.293	-4.7
11	Turbidity	NTU	-0.189	-2.79	-0.309	-4.59	-0.201	-2.94
12	BOD	mg/l	0.266	4.149	0.094	1.465	-0.009	-0.14
13	COD	mg/l	0.234	3.753	0.081	1.309	-0.011	-0.18
14	Do	NTU	0.174	2.804	0.092	1.479	0.269	4.32

Uniform patterns were detected in Ca, Cl and Na in case of both parametric and non-parametric methods. Ca, Cl and Na increased at all of the stations in the study period. Calcium is present probably because of the disposal of sewage and industrial wastes into the river whereas the most important source of chlorides is the discharge of domestic sewage. Man and other animals excrete very high quantities of chlorides together with nitrogenous compounds. Many industrial wastes and domestic sewage are rich in sodium and increase its concentration in natural waters after disposal.

Electrical conductivity also showed an increasing trend at Sangam, Ram munshibagh and Saffapora in case of non- parametric method.Significant positive trends were found in Na, Ca, and Cl. The increasing Ca trends were significant at the 95% confidence levels by the tests at Sangam, Ram Munshibagh and Saffapora by both parametric and non-parametric methods. The annual concentrations of Ca increased by 0.02(Z = 5.72), 0.03 (Z = 8.916) and 0.02 (Z = 7.68) mg/l per decade at Sangam, Ram munshibagh and Saffapora respectively. Significant positive trends in Na with concentration of about 0.02(Z = 5.72), 0.01(Z = 8.91) and 0.01(Z = 7.68) mg/l were observed at the 95% confidence level (by both parametric and non-parametric method) over Sangam, Ram munshibagh and Saffapora respectively. The decreasing turbidity trends were significant by non- parametric at Sangam, Ram munshibaghandSaffapora at 95% confidence level (Z = -2.790, -4.590and -2.94 respectively). Furthermore, significant negative trends were observed in Potassium (-0.008 mg/l per decade) at Ram munshibagh and sulphate over Sangam (Z = -2.69) and Saffapora (Z = -1.30), by non- parametric method at 95% confidence level. This condition arises when organic matter is high and redox potential is low. Under such conditions micro-organisms use sulphate as electron acceptor to decompose organic matter and convert sulphate into sulphide. Total phosphorus showed significant positive trends at Sangam Ram munshibagh and Saffapora by non- parametric method whereas Total phosphate showed positive trend only at Ram munshibagh in case of parametric method (95% confidence level).

The study showed that the most significant trends were found at Ram munshibagh site which is located towards the downstream of River Jehlum. Moreover, comparison of the parametric and non-parametric methods indicated that the nonparametric tests identified more significant trends than the parametric method. The parametric and non-parametric methods detected seventeen and twenty eight significant trends in annual water quality parameters, respectively. Overall, the results exhibited that the concentrations of the water quality parameters of the River Jehlum increased during the study period. This increase is a result of continuing loading of the river with pollutants related to human activities and lack of appropriate management plan.

4.2 Seasonal trends:

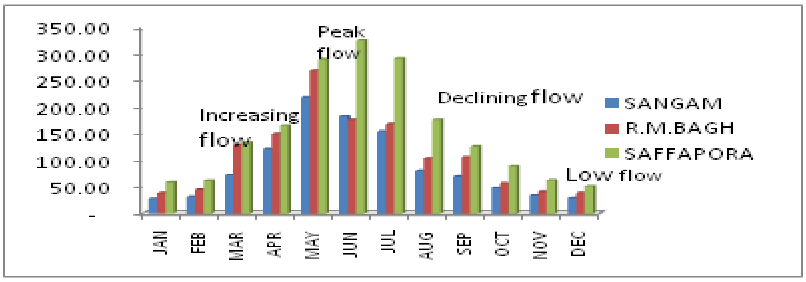

Fig. 2: Mean monthly stream-flow (2003-2012) at monitoring station in order to define hydrologic seasons.

Seasonal patterns, which occur yearly regardless of longer term trends, are normally examined as an aid to understanding the natural patterns of chemical concentrations. In the present study, seasons are defined by reviewing histograms of monthly mean stream flow for chemical patterns (Fig.2). The time periods of the season may be unequal in length but they represent distinct hydrological periods. Hydrologic seasons generally do not define periods of similarity in conditions, like "summer" or "winter" does for climate, but rather directional tendencies. The yearly stream flow patterns were similar within the three stations with all sites exhibiting peak discharge between March and September. Clearly these time periods are dissimilar in length but represent periods which are distinct hydro-logically.

Mann–Kendall test and linear regression were also applied in order to study trends in seasonalmeans of the water quality parameters over the study period (2003–2012). Seasonal trends of the water quality parameters and their magnitude obtained by the statistical methods are summarized in Tables 3 to 10 below:

Table 3:Parametric method (Spring)

PARAMETERS /STATIONS		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	R^2	SLOPE	R^2	SLOPE	R2	SLOPE
1	Ph	0.066	5.00E-05	0.214	0	8.00E-05	-8E-06x
2	EC	0.316	0.033	0.237	0.025	0.211	0.064
3	CALCIUM	0.336	0.004	0.482	0.005	0.229	0.003
4	MAGNESIUM	0.113	0.001	0.067	0	0.11	0.001
5	CHLORIDE	0.42	0.001	0.683	0.002	0.65	0
6	BICARBONATE	0.203	0.01	0.322	0.013	0.026	0.003
7	SODIUM	0.188	0	0.487	0.001	0.294	0
8	POTASSIUM	0.015	5.00E-05	0.002	2.00E-05	0.027	-8.00E-05
9	TOTAL-P	0.168	2.00E-05	0.507	4.00E-05	0.08	1.00E-05
10	SULPHATE	0.119	0	0.002	7.00E-05	0.002	5.00E-05
11	TURBIDITY	0.325	-7.00E-05	0.46	-0.001	0.011	-1.00E-05
12	BOD	0	-5.00E-06	0.012	-3.00E-05	0.386	0
13	COD	0.006	0.001	0.047	-0.003	0.185	-0.006
14	DO	0.07	0	0.075	0	0.162	0

Table 4:Non-Parametric Method (Spring)

Parameters/station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	KENDALL'S TAU	Z	KENDALL'S TAU	Z	KENDALL'S TA	Z
1	Ph	0.18	1.38	0.3	2.23	-0.08	-0.5
2	EC	0.37	2.87	0.32	2.48	0.35	2.68
3	CALCIUM	0.36	2.72	0.59	4.49	0.32	2.42
4	MAGNESIUM	0.17	1.29	0.13	1	0.15	1.13
5	CHLORIDE	0.65	2.2	0.758	5.83	0.66	0.54
6	BICARBONATE	0.31	2.36	0.43	3.29	0.06	0.46
7	SODIUM	0.21	1.61	0.45	3.48	0.42	3.23
8	POTASSIUM	-0.02	-0.11	0.06	0.41	-0.1	-0.77
9	TOTAL-P	0.28	2.13	0.67	5.16	0.16	1.2
10	SULPHATE	-0.17	-1.31	0.11	0.82	0.1	0.77
11	TURBIDITY	-0.45	-3.24	-0.46	-3.35	-0.13	-0.87
12	BOD	0.05	0.33	0.03	0.2	0.51	3.77
13	COD	0.1	0.73	-0.04	-0.32	-0.17	-1.27
14	DO	0.22	1.68	0.09	0.7	0.31	2.38

In Tables 3 and 4, the majority of the trends in the spring series (more than 80% of the trends) were found positive. Significant trends were observed in almost all of the water quality parameters. Furthermore, Electrical conductivity, Ca, Na, Turbidity trends were significant at all the sites. The most significant trends were found at Sangam and Ram Munshibagh sites. Linear regression and Mann- Kendall tests detected 24 and 32 significant trends respectively in the spring time series.

Table 5: Parametric Method (summer)

Parameters/ Station		SANGAM		RAM MUNSHIBAGH		Saffapora	
S.NO	PARAMETER	R2	SLOPE	R2	SLOPE	R2	SLOPE
1	Ph	0.205	-0.001	0.403	- 0.0	0.025	8.00E-05
2	EC	0.003	0.002	0	0.001	0.054	-0.011
3	CALCIUM	0.143	-0.001	0.215	-0.002	0.348	-0.004
4	MAGNESIUM	0.027	0	0.142	-0.001	0.088	0
5	CHLORIDE	0.571	0.001	0.58	0.002	0.56	0.001
6	BICARBONATE	0.096	0.008	0.015	0.002	0.108	0.004
7	SODIUM	0.439	-0.001	0.652	0.001	0.643	0.001
8	POTASSIUM	0.131	-9.00E-05	0.036	5.00E-05	0	-1.00E-05
9	TOTAL-P	0.011	-4.00E-06	0.207	2.00E-05	0.048	8.00E-06
10	SULPHATE	0.231	-0.002	0.025	9.00E-05	0.565	0
11	TURBIDITY	0.146	-5.00E-05	0.169	-6.00E-05	0.168	-5.00E-05
12	BOD	0.324	-0.001	0.335	-0.001	0.174	-0.001
13	COD	0.006	-0.001	0.123	-0.005	0.322	-0.01
14	DO	0.039	-0.001	3.00E-07	-6.00E-07	0.004	-6.00E-05

Table 6: Non-Parametric Method (summer)

Parameters/station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	KENDALL'S TAU	Z	KENDALL'S TAU	Z	KENDALL'S TA	Z
1	Ph	0.18	1.38	0.3	2.23	-0.08	-0.5
2	EC	0.37	2.87	0.32	2.48	0.35	2.68
3	CALCIUM	0.36	2.72	0.59	4.49	0.32	2.42
4	MAGNESIUM	0.17	1.29	0.13	1	0.15	1.13
5	CHLORIDE	0.65	2.2	0.758	5.83	0.66	0.54
6	BICARBONATE	0.31	2.36	0.43	3.29	0.06	0.46
7	SODIUM	0.21	1.61	0.45	3.48	0.42	3.23
8	POTASSIUM	-0.02	-0.11	0.06	0.41	-0.1	-0.77
9	TOTAL-P	0.28	2.13	0.67	5.16	0.16	1.2
10	SULPHATE	-0.17	-1.31	0.11	0.82	0.1	0.77
11	TURBIDITY	-0.45	-3.24	-0.46	-3.35	-0.13	-0.87
12	BOD	0.05	0.33	0.03	0.2	0.51	3.77
13	COD	0.1	0.73	-0.04	-0.32	-0.17	-1.27
14	DO	0.22	1.68	0.09	0.7	0.31	2.38

The results of the statistical methods in the summer series (table 5 and 6) showed that more than 68% of the trends were negative. All of the water quality parameters except EC, Total-phosphorus, K, and HCO3 parameters were characterized by a significant trend. In the summer series, Sangam and Ram Munshibagh had the most significant trends. 33 and 25 significant trends were identified by the Mann–Kendall test and linear regression respectively.

Table 7: Parametric Method(Autumn)

Parameters/ station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	R2	SLOPE	R2	SLOPE	R2	SLOPE
1	Ph	0.031	-8.00E-05	0.002	-2.00E-05	0.061	-0.0003
2	EC	0.004	-0.002	0.112	-0.029	0.065	-0.007
3	CALCIUM	0.076	0.001	0.252	0.001	0.175	0.001
4	MAGNESIUM	0.02	0	0.123	-0.001	0.207	-0.001
5	CHLORIDE	0.444	0.001	0.467	0.001	0.303	0.001
6	BICARBONATE	0.009	0.001	0.248	0.01	0.015	-0.001
7	SODIUM	0.318	0.001	0.606	0.001	0.429	0.001
8	POTASSIUM	0.096	7.00E-05	0.158	-0.003	0.022	0
9	TOTAL-P	0.001	9.00E-07	0.114	-1.00E-05	4.00E-05	-2.00E-07
10	SULPHATE	0.024	1.00E-04	0.019	-0.001	0.594	-0.002
11	TURBIDITY	0.042	-3.00E-05	0.03	-1.00E-05	0.013	-1.00E-05
12	BOD	0.219	-0.001	0.003	-2.00E-05	0.124	-0.001
13	COD	0.187	-0.002	0.6	-0.012	0.051	-0.004
14	DO	0.187	-0.003	0.059	0	0.255	-0.001

Table 8: Non-Parametric Method (Autumn)

Parameters/station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	KENDALL'S TAU	Z	KENDALL'S TAU	Z	KENDALL'S TAU	Z
1	Ph	-0.019	-0.126	0.134	1.003	-0.107	-0.79
2	EC	-0.051	-0.375	-0.19	-1.446	-0.221	-1.68
3	CALCIUM	0.192	1.396	0.385	2.904	0.304	2.268
4	MAGNESIUM	-0.043	-0.306	-0.407	-3.125	-0.453	-3.48
5	CHLORIDE	0.587	4.487	0.638	4.88	0.525	4.036
6	BICARBONATE	0.065	0.482	0.463	3.539	-0.068	-0.54
7	SODIUM	0.522	3.986	0.715	5.485	0.542	4.162
8	POTASSIUM	-0.133	-0.942	-0.259	-1.938	0.077	0.558
9	TOTAL-P	0.091	0.679	0.304	2.337	-0.051	-0.37
10	SULPHATE	-0.273	-2.047	-0.177	-1.341	-0.395	-2.98
11	TURBIDITY	-0.089	-0.617	-0.154	-1.034	-1	-0
12	BOD	-0.311	-2.286	-0.019	-0.162	-0.301	-2.28
13	COD	-0.567	-4.337	-0.624	-4.823	-0.201	-1.57
14	DO	-0.347	-2.696	-0.233	-1.805	-0.435	-3.37

Similar to the summer series, most of the trends in the autumn time series (more than 60% of the trends) were negative (Tables 7 and 8). The results also indicated that no significant trends were detected by the trend tests in half of the water quality parameters. Significant trends were observed in Na, Cl and SO4. The most significant trends in the autumn series were found at Ram Munshibagh. The non-parametric and parametric methods detected thirty and twenty one significant trends in the autumn time series.

Table 9: Parametric Method (Winter)

Parameters/station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	R2	SLOPE	R2	SLOPE	R2	SLOPE
1	Ph	0.033	-6.00E-05	4.00E-06	4.00E-07	0.012	4.00E-05
2	EC	0.221	0.017	0.289	0.043	0.179	0.048
3	CALCIUM	0.171	0.001	0.323	0.002	0.095	0.001
4	MAGNESIUM	0.007	0	0.321	0.002	0.18	0.002
5	CHLORIDE	0.311	0.001	0.398	0.001	0.136	0.001
6	BICARBONATE	0.089	0.006	0.211	0.009	0.078	0.004
7	SODIUM	0.103	0	0.473	0.001	0.249	0.001
8	POTASSIUM	0.166	0	0.287	0	0.002	-6.00E-05
9	TOTAL-P	0.397	3.00E-05	0.656	5.00E-05	0.152	2.00E-05
10	SULPHATE	0.231	0	0.506	-0.001	0.424	-0.001
11	TURBIDITY	0.039	2.00E-05	0.102	4.00E-05	0.113	-4.00E-05
12	BOD	0.225	0	0.033	5.00E-05	0.393	0
13	COD	0.494	0.009	0.003	0.001	0.211	0.006
14	DO	0.192	0	0.126	0	0.281	0.001

Table 10: Non-Parametric Method (Winter)

Parameters/station		SANGAM		RAM MUNSHIBAGH		SAFFAPORA	
S.NO	PARAMETER	KENDALL'S TAU	Z	KENDALL'S TAU	Z	KENDALL'S TAU	Z
1	Ph	-0.071	-0.52	0.029	0.1981	0.113	0.829
2	EC	0.363	2.786	0.526	0.001	0.406	3.109
3	CALCIUM	0.278	2.058	0.443	3.351	0.213	1.595
4	MAGNESIUM	0.047	0.341	0.454	3.482	0.291	2.216
5	CHLORIDE	0.621	4.727	0.637	4.908	0.336	2.572
6	BICARBONATE	0.229	1.75	0.386	2.963	0.208	1.589
7	SODIUM	0.278	2.111	0.649	4.998	0.554	4.237
8	POTASSIUM	-0.303	-2.278	-0.314	-2.338	-0.189	-1.42
9	TOTAL-P	0.426	3.269	0.632	4.843	0.231	1.767
10	SULPHATE	-0.259	-1.967	-0.408	-3.125	-0.4	-3.07
11	TURBIDITY	0.037	0.241	-0.264	-1.83	-0.28	-1.96
12	BOD	-0.265	-1.991	0.06	0.433	-0.457	-3.42
13	COD	0.533	4.048	0.189	1.445	0.39	2.999
14	DO	0.317	2.429	0.161	1.231	0.373	2.857

Similar to the spring time series, the majority of the trends in the winter series (about 80% of the trends) were positive (Tables 9 and 10). All of the water quality parameters except to Sulphate, K, and turbidity parameters were characterized byan increase in trend. In the winter series, Saffapora and Ram munshibagh stations had the most significant trends. The non-parametric tests found 37 significant trends while 30 significant trends were determined by the parametric method in the winter series.

In water quality monitoring and planning, winter low flows are often the time of the highest concentrations, whereas the late spring and early summer months are the time when dilution occurs due to greater volumes of discharge [9]. Generally, high flows occur duringspring and early summer (primarily from snowmelt or rainfall runoff from spring storms) and low flows occur during late fall and winter (primarily from ground-water or reservoir discharges) as also indicated by Fig 2. For the spring period of April and May River Jhelum shows significant positive trends [12]. In contrast, the early summer period of June and July has predominantly negative trends. Whereas late summer (August and September) has a nearly equal number of negative and positive trends and late winter trends are also predominantly positive.Furthermore, the strongest positive trend (Z=5.83, b (slope) =0.2mg/l per decade) was observed in Chloride series in spring at Ram munshibagh. In contrast, the strongest negative trend (Z = -1.58, b (slope) =0.3mg/l per decade) was found in Sulphate series in summer at Saffapora station.

V. CONCLUSION

Trend analysis showed that significant positive trends were showed by Sodium, Chloride, and Calcium at Sangam, Ram Munshibagh and Saffapora by both parametric and non-parametric methods.The decreasing turbidity trends were significant by non- parametric at Sangam, Ram Munshibagh and Saffapora at 95% confidence level (Z = - 2.790, - 4.590 and - 2.94 respectively). The study showed that the most significant trends were found at Ram Munshibagh site. The results revealed that the concentrations of the water quality parameters increased in spring and winter seasons, whereas the concentrations were diluted in summer and autumn seasons during the study period.

The majority of the differences between the results of the non-parametric and parametric methods were observed in the autumn series (Mann-Kendall test showed 30 trends and regression showed 21 trends). In general, parametric tests are more powerful for normally distributed data compared with the non-parametric tests. The correct use of parametric methods requires several assumptions to be fulfilled, including the type of distribution (most frequently normal), serial independence (i.e., zero autocorrelation), and stationary. However, these assumptions are frequently violated by environmental and hydrological data or are difficult to verify. Non-parametric (distribution free) methods, which relax the parametric assumptions, may serve as an alternative. They tend to be more resistant to any misbehavior of the data than the parametric methods, at the expense of being less efficient. That is, they have larger uncertainty in the statistical estimate [13]. Considering that non-parametric methods are much more powerful than parametric ones for non-normally distributed data, therefore, nonparametric methods are suggested for detecting trends in water quality data that may not normally distributed.

REFERENCES

[1] Antonopoulos, Vassilis, Papamichail, Dimitris Mitsiou, Konstantina, Statistical and Trend Analysis of Water Quality and Quantity Data for the Strymon River in Greece, Hydrology and Earth System Sciences,5(4),2001, 679-691.
[2] Tsanis I.K, El-Shaarawi, Trend evaluation of water quality parameters in the Niagara and St. Lawrence rivers, Environmental Monitoring and Assessment,23, 1993, 205-218.
[3] Evans et al, Surface Water Acidification in the South Pennines II. Temporal Trends, Environmental Pollution (Elsevier),109(1), 2000, 21-34.
[4]Raike A., Pietilainen O.P., Rekolainen S., Kauppila P., Pitkanen H., Niemi J., Raateland A. and Vuorenmaa, J., Trends of phosphorus, nitrogen and chlorophyll a concentrations in Finnish rivers and lakes in 1975-2000, The Science of the TotalEnvironment, 30, 2003, 47-59.
[5]Naddafi K., Honari H., AhmadiM., Water quality trend analysis for the Karoon River in Iran, Environmental Monitoring and Assessment,134,2007, 305-312
[6] Kannel PR, Lee S, Kanel SR, Khan SP, Lee YS, Spatial-temporal variation and comparative assessment of water qualities of urban river system: a case study of the river Bagmati (Nepal), Environmental Monitoring and Assessment, 129,2007, 433-459
[7]Chang, Spatial analysis of water quality trends in the Han River basin, South Korea,Water Research (Elsevier), 42, 2008, 3285–3304.
[8] Bouza-Deano R., Ternero-Rodriguez M., Fernandez-Espinosa A.J., Trend study and assessment of surface water quality in the Ebro River,Journal Of Hydrology (Amsterdam), 1, 2008, 227-239
[9] HosseinTabari , Safar Marofi ,Mohammad Ahmadi, Long-term variations of water quality parametersin the Maroon River, Iran, Environmental Monitoring and Assessment,2010.
[10] Gilbert, R.O., Statistical Methods for Environmental Pollution Monitoring(USA, John Wiley and Sons, 1987).
[11] Partal, T., and Kahya, E., Trend analysis in Turkish precipitation data. Hydrological Processes, 20, 2006, 2011–2026.
[12] Archer D.R., Fowler H.J.,Using meteorological data to forecast seasonal runoff on the River Jhelum, Pakistan, Journal of Hydrology,361, 2008, 10–23.
[13] Huth R., Pokorna L., Parametric versus nonparametric estimates of climatic trends, Theoretical and Applied Climatology, 77, 2004, 107–112.