International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 03, March-2019

EFFECTS OF THE TRIBUTARIES ON WATER QUALITY PARAMETERS OF RIVER JHELUM

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Abstract
The present study was carried out with an aim to assess the water quality parameters at different sites of upper River Jhelum along its course from its source Verinag up to Baramulla. Also, the water quality parameters of three tributaries namely Lidder river, Vishow Nallah and Romshi Nallah were determined and the effects of these tributaries on the water quality of River Jhelum were assessed. It was observed that the concentration of physical and chemical parameters varied with respect to the collection sites along the course of River Jhelum. The study helps in identifying the sites that require attention for a sustainable development of the environment and summons the need to take necessary measures at specific locations for controlling various parameters which are close to or beyond standard permissible limits.

Keywords: River Jhelum; Water Quality; Lidder River; Parameters; Tributaries.

I. INTRODUCTION

Jhelum River flows in India and Pakistan. It is a tributary of the Chenab and has a total length of about 725 kilometres (450 mi) with an average discharge of 221.9 m^3/s. River Jhelum rises from Verinag Spring situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir in India. It flows through Srinagar and the Wular Lake before entering Pakistan through a deep narrow gorge. In the upstream of River Jhelum, Lidder river is its most prominent tributary which originates from Kolhoi glacier and flows in gorges between mountains for most of its length and finally merges with Jhelum River at Mirgund Khanabal at an altitude of 1615 m from MSL. The length of this tributary is about 70 km and its total catchment area is 580 km^2. Another noteworthy tributary of River Jhelum is Vishow Nallah which originates from the foot hills of Pir Panchal range between Sidan and Banihal ranges. This tributary merges with Jhelum river at Sangam. The total length of Vishow Nallah is about 60 km and its catchment area is about 1200 km^2. Other important tributaries in upper River Jhelum is Rambiara Nallah, Romshi Nallah, Dudhganga river, Sindh river, and Pohroo Nallah. In the downstream of River Jhelum, the largest tributary Neelam River joins it at Domel Muzaffarabad. It is then joined by Kunhar River and the Poonch River and flows into the Mangla Dam reservoir in the district of Mirpur. The Jhelum enters the Punjab in the Jhelum District. From there, it flows through the Pakistan's Punjab, forming the boundary between the Chaj and Sindh sagar Doabs. It ends in a confluence with the Chenab at Trimmu in District Jhang. The Chenab merges with the Sutlej to form the Panjnab River which joins the Indus River at Mithankot.
The three tributaries which have been considered in the present study are Lidder River of District Anantnag, Vishow Nallah of District Kulgam and Romshi Nallah of District Budgam. The water samples were collected from lower Lidder River, lower Vishow Nallah and lower Romshi Nallah to determine their physicochemical properties just above their confluence with river Jhelum. Also, the water samples from five sites of the River Jhelum were collected and the samples were analysed for detection of variation in Physico-chemical properties of River Jhelum.
Water Quality is defined as the chemical, physical and biological characteristics of water in relation to the fixed standards (Gupta et al. 2011; Samantray et al. 2009). Water quality standards are followed to ensure efficient use of water for a designated use. Also, it is necessary to maintain a good health of a water body by close monitoring of the various water quality parameters which may be physical parameters (such as turbidity, odour, colour, pH value and total hardness) or chemical parameters (such as Calcium, Magnesium, Dissolved Oxygen, Alkalinity, Acidity, Nitrate, Phosphate, Chlorides, Fluorides, Carbon Dioxide, and Iron) (Akubugwo 2013; Amadi 2010; Dey et al. 2005; Haritash 2016).

II. Test Procedure

For assessing the water quality of the River Jhelum and the effect of tributaries on the water quality of main-river along its course, the following parameters were determined:
Turbidity, Odour, Colour, Conductivity, pH, TDS, Total hardness, Calcium, Magnesium, Dissolved Oxygen, Alkalinity, Acidity, Nitrate, Phosphate, Chlorides, Fluorides, Carbon dioxide, and Iron.
Once the parameters to be determined were chosen, it was necessary to select the sites from where samples could be taken and analysed in the laboratory.

Water samples from Tributaries of Jhelum: The samples from tributaries were taken in the downstream side of tributaries but well above their confluence with River Jhelum to ensure the actual quality of water of tributary before mixing with that of River Jhelum is determined. Thus samples from Lidder River were taken approximately 3 km above its confluence with Jhelum River and the samples from Vishow Nallah and Romshi Nallah were taken approximately 2 km above their confluences with the Jhelum River.

Water samples from Jhelum River: One set of water samples from river Jhelum was taken well above its confluence with the tributaries so that the water quality of River Jhelum before merging with its tributary is taken. As such, the samples were taken approximately 2 km upstream of confluence. These sites have been designated as Khanabal (u/s), Sangam (u/s) and Kakapora (u/s).

The other set was collected well below the confluence with the tributary so that there is thorough intermixing of waters from the tributary and the Jhelum River. The mixing length concept was used and Andre's formula was employed to approximately calculate the mixing length, L_{mixing} (in metres):

$$L_{mixing} = C\, Q^{1/3}\, B$$

Here C is constant whose value is taken to be 8 for small and medium size rivers, Q is discharge of river (m^3/s) and B is average breadth of the river below confluence (m). For Lidder river draining water in Jhelum river, Avg. Q = 206 m^3/s and B = 84 m, the mixing length is about 416 m. Thus the sample should be collected downstream of this point. For Vishow Nallah L_{mixing}= 4161 m and Romshi Nallah L_{mixing}= 4550 m. The samples were taken approximately 6 km downstream of confluences of Lidder River, Vishow Nallah and Romshi Nallah respectively.

These sites have been designated as Khanabal (d/s), Sangam (d/s) and Kakapora (d/s).

For assessing the variation of physicochemical characteristics along the course of Jhelum River, three more sites for sample collection were selected; these sites are Verinag, Padshahibagh in Srinagar and Baramulla, thereby making the total of 12 collection sites; nine from River Jhelum and three from the tributaries chosen.

Proper sampling and testing needs to be ensured to obtain the exact results (Gupta et al. 2011; Kadhem 2013; Khan et al. 2012; Yaseen et al. 2015. Some of the prominent water quality assessment parameters are described as follows.

pH of water is a measure of amount of hydrogen ions that is present in the water. It determines if the water is alkaline or acidic in nature. pH stands for potential of hydrogen. As per the World Health Organization (WHO), the value of pH for drinking water is 6.5 to 8.5.

Turbidity is the cloudiness or haziness in the water caused by large numbers of individual particles e.g. Clay silt, finely divided organic/inorganic matter, soluble compounds, planktons, micro-organisms, etc. that are generally invisible to the naked eye, similar to smoke in air. The propensity of particles to scatter a light beam focused on them is now considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a nephelometer with the detector set up to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (NTU).

The suspended particles in water are visible to the naked eye and they can be removed by the process of sedimentation or filtration through filter. But the dissolved particles are not visible to eye and simple filtration doesn't remove it. Total Dissolved Solids can be found by evaporating the water sample.

Hardness of water is determined by the concentration of multivalent cations in the water. Multivalent cations are positively charged metal complexes with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca^{2+} and Mg^{2+}. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). Rainwater and distilled water are soft, because they contain few ions. The hardness caused by bicarbonates of magnesium and calcium is known as temporary or carbonate hardness. The non-carbonate hardness is called permanent hardness because it cannot be removed by single boiling.

Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. Alkalinity is the strength of a buffer solution composed of weak acids and their conjugate bases. It is measured by titrating the solution with a monoprotic acid such as HCl or H_2SO_4 until its pH changes abruptly, or it reaches a known endpoint where that happens. Alkalinity is expressed in units of meq/L (milliequivalents per liter), which corresponds to the amount of monoprotic acid added as a titrant in millimoles per litre.

III. Results and discussions

The results of the physical characteristics of the water of Jhelum River at nine different sites along the river course and three sites of tributaries are presented in Table 1. Figures 1, 3, 5 and 7 give the variations of the physical parameters at selected sites of main river Jhelum while Figures 2, 4, 6 & 8 show the relative change/effect on these parameters due to the three tributaries namely Lidder River, Vishow Nallah and Romshi Nallah on Jhelum River water.

Table 1. Physical Characteristics of the water samples at different sites

S. No.	Place	Turbidity (NTU)	Odour	Colour (Hazen)	pH Value	Total Hardness (mg/l)	Conductivity (μS/cm)
1	Verinag (u/s)	28.5	Unobjectionable	20	7.88	140	316
2	Khanabal (u/s)	25.5	Unobjectionable	15	7.86	150	364
3	Khanabal (d/s)	19.3	Unobjectionable	20	7.39	104	289
4	Sangam (u/s)	18.6	Unobjectionable	20	7.35	102	290
5	Sangam (d/s)	16.1	Unobjectionable	25	7.40	94	271
6	Kakapora(u/s)	18.2	Unobjectionable	30	7.41	78	271
7	Kakapora(d/s)	17.5	Unobjectionable	35	7.45	76	208
8	Padshahibagh	38	Unobjectionable	30	7.95	104	165.8
9	Baramullah	56	Unobjectionable	25	7.40	90	188.5
10	Lidder	13.5	Unobjectionable	20	7.27	70	170.2
11	Vishow	4.81	Unobjectionable	30	7.54	50	62.9
12	Romshi	15.3	Unobjectionable	45	7.54	70	117.9

Figure 1. Variation of turbidity along ithe course of River Jhelum

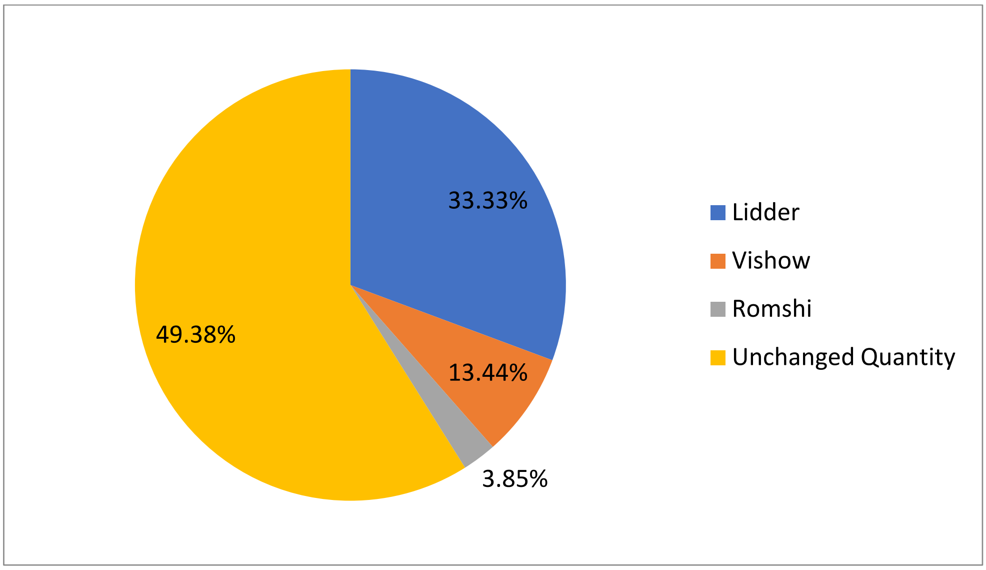

Figure 2. Relative change of turbidity (NTU) by the different tributaries of River Jhelum

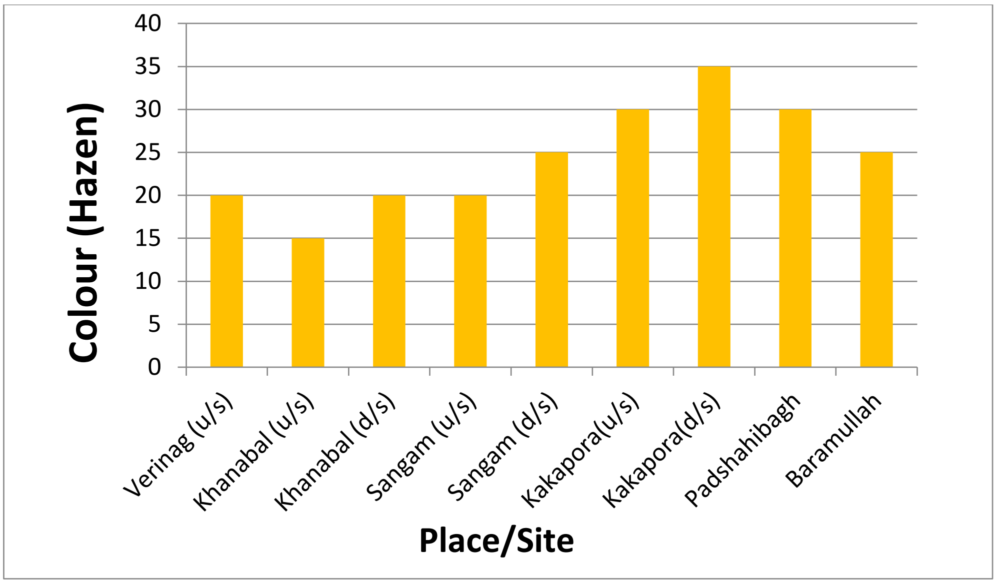

Figure 3. Variation of Colour (Hazen) along the course of River Jhelum

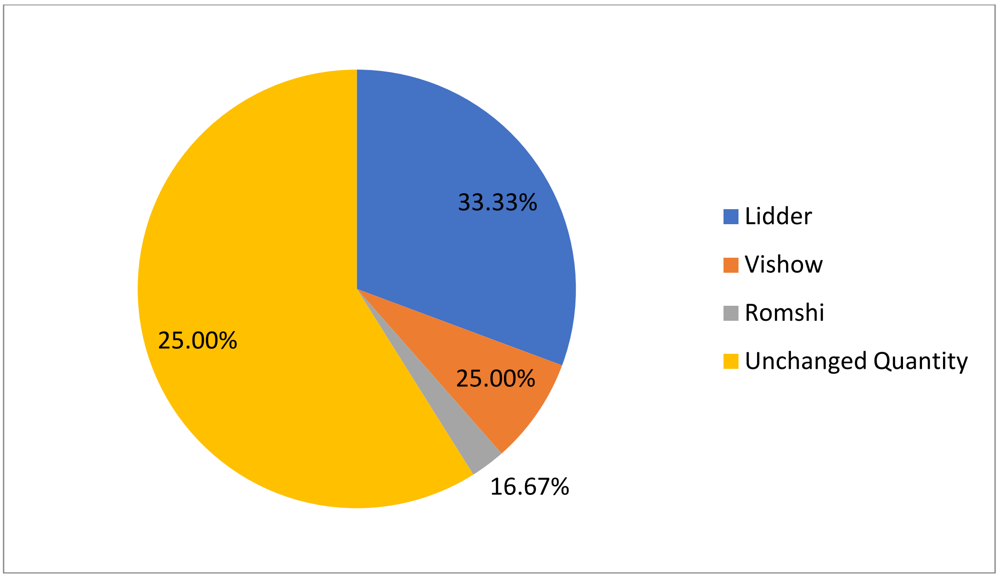

Figure 4. Relative change of colour by different tributaries of River Jhelum

Figure 5. Variation of pH along the course of River Jhelum

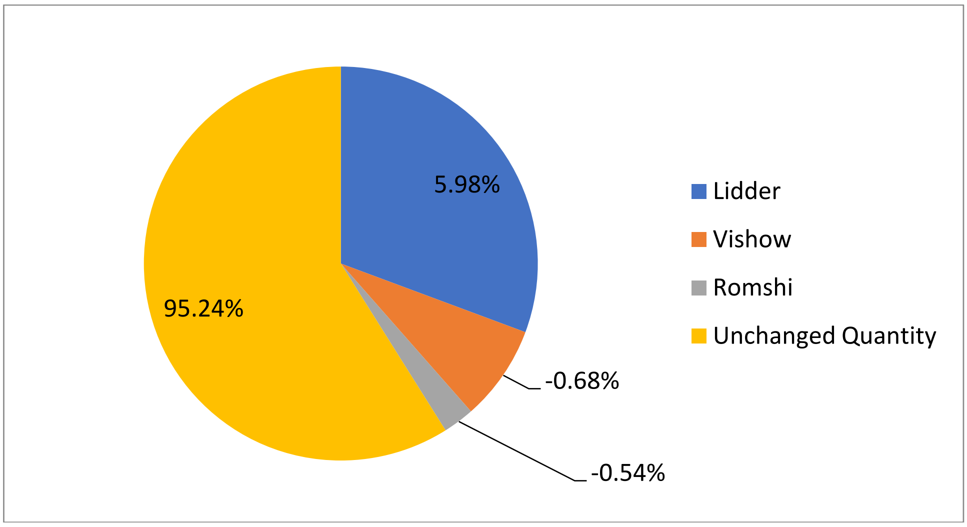

Figure 6. Relative Change of pH by different tributaries of River Jhelum

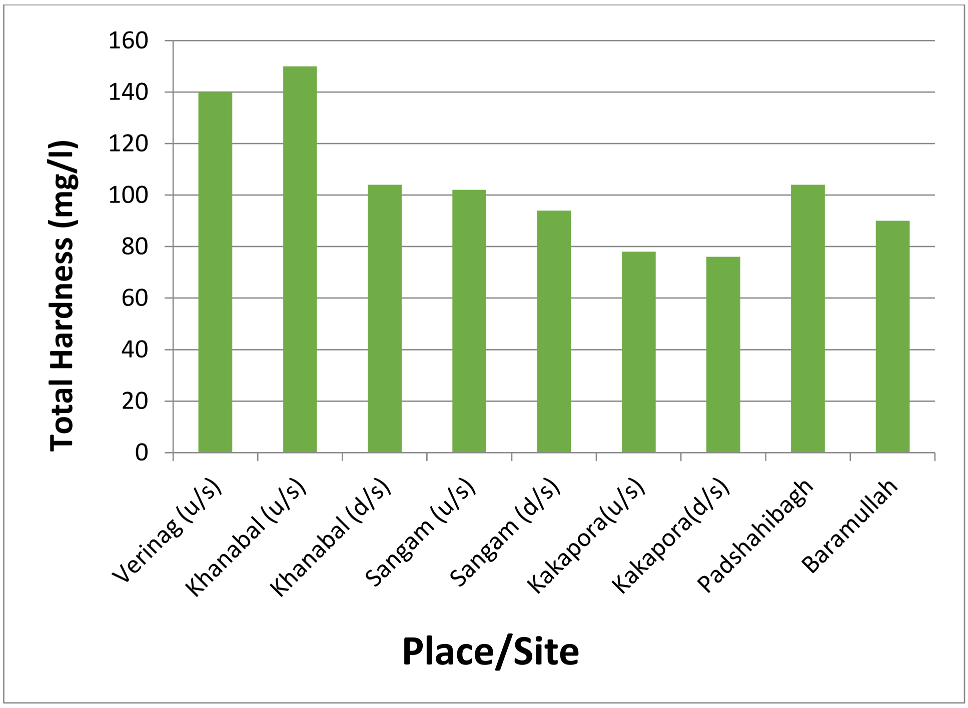

Figure 7. Variation of total hardness along the course of River Jhelum

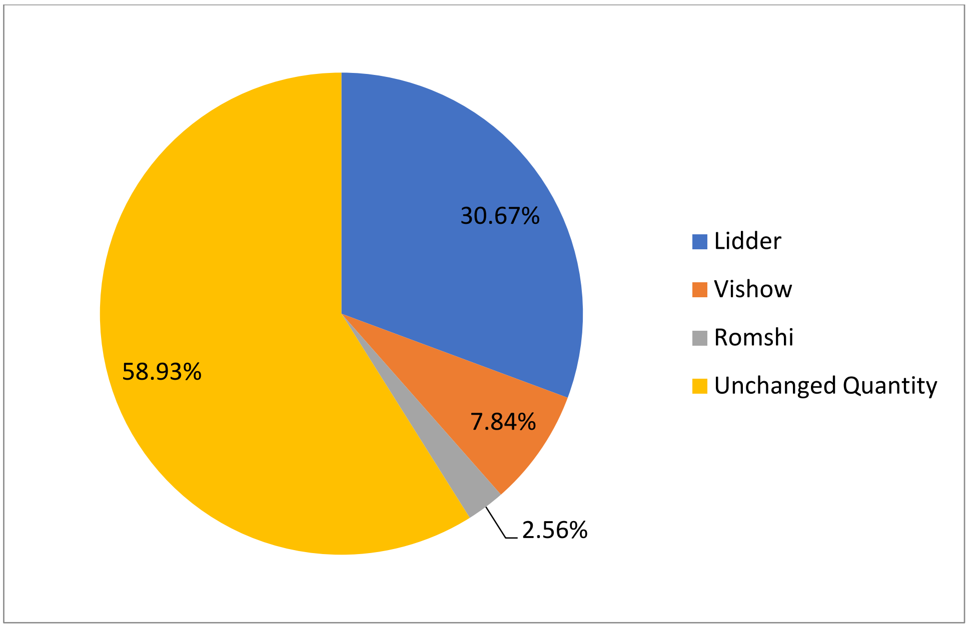

Figure 8. Relative Change of total hardness by different tributaries of River Jhelum

The variation of conductivity along the course of Jhelum River from Verinag to Baramulla and the impact of tributaries on the conductivity of Jhelum water can be similarly presented.
It is obvious that among the tributaries chosen for study, Lidder River has most prominent impact on water quality parameters of Jhelum River due to its highest contribution to the discharge of Jhelum River. However the impact is not exactly proportional to the amount the discharge drained by different tributaries into River Jhelum which may be attributed to seepage of ground water into Jhelum River through its bed or sides in spring or early summer seasons. In autumn and early winter, the water may percolate or seep out to the ground due to lowering of water table. Besides these, there are other tributaries like Bringi Nallah, Rambara Nallah, Kuthar on the very upstream of Jhelum River which lay some impact on its water quality. Pohroo Nallah, Dudhganga and Sindh river merge into Jhelum River downstream of Kakapora and casts much effect on the physic-chemical parameters of Jhelum River water.
The samples were tested for chemical parameters as well. Tables 2(a)-2(b) give the laboratory results for the various chemical parameters of water. The variation of some of these parameters along the course of Jhelum River have been represented by Figures 9, 11, 13 and 15 and the relative impact of tributaries for these parameters on the Jhelum river water have deciphered via Figures 10, 12, 14 and 16.

Table 2(a). Chemical Characteristics of the water samples at different sites

S. No.	Place	Calcium (mg/l)	Magnesium (mg/l)	TDS (mg/l)	DO content (mg/l)	Total Alkalinity (mg/l)	CO_2 (mg/l)
1	Verinag spring	49.6	6.344	182	4.80	144	3
2	Khanabal (u/s)	42.4	2.44	144	4.60	108	4
3	Khanabal (d/s)	32.4	3.44	138	4.70	88	3
4	Sangum (u/s)	27.7	3.86	137	4.66	82	3
5	Sangum (d/s)	26.2	4.06	136	4.72	74	2.8
6	Kakapora (u/s)	24	4.39	136	4.41	60	3
7	Kakapora (d/s)	22	4.39	133	4.38	56	3
8	Padshahibagh	18.4	19.10	82.6	6.13	72	4.1

9	Baramullah	22.4	3.42	94.2	4.65	52	4.65
10	Lidder	18	5.86	85.1	4.93	86	2
11	Vishow	7.2	7.81	31.5	4.74	66	1
12	Romshi	20	4.39	58.9	5.68	50	1.5

Table 2(b). Other Chemical Characteristics of the water samples at different sites

S. No.	Place	Phosphate (mg/l)	Acidity (mg/l)	Nitrate (mg/l)	Chloride (mg/l)	Fluoride (mg/l)	Iron (mg/l)
1	Verinag	0.1	0.1	12	20	0.22	0.1
2	Khanabal (u/s)	0.07	0.07	20	22	0.20	0.07
3	Khanabal (d/s)	0.06	0.06	18	21	0.19	0.06
4	Sangum (u/s)	0.06	0.07	17	26	0.20	0.07
5	Sangum (d/s)	0.07	0.07	14	25	0.20	0.08
6	Kakapora (u/s)	0.06	0.06	16	46	0.22	0.06
7	Kakapora (d/s)	0.07	0.06	15	43	0.24	0.06
8	Padshahibag	0.32	0.32	15	30	0.35	0.32
9	Baramullah	0.08	0.08	18	24	0.28	0.08
10	Lidder	0.04	0.04	8	20	0.18	0.04
11	Vishow	0.09	0.08	5	22	0.15	0.09
12	Romshi	0.08	0.09	13	20	0..26	0.09

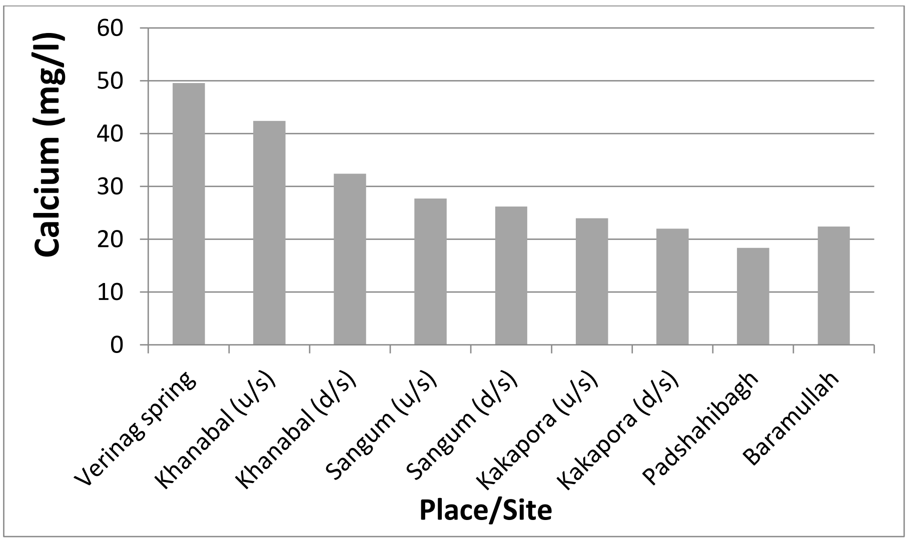

Figure 9. Variation of Calcium content along the course of River Jhelum

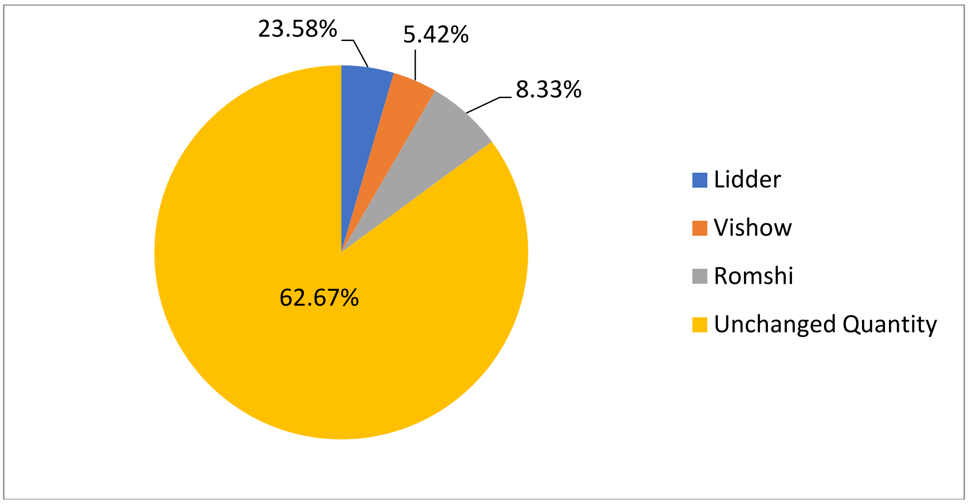

Figure 10. Relative change in Calcium content by different tributaries of River Jhelum

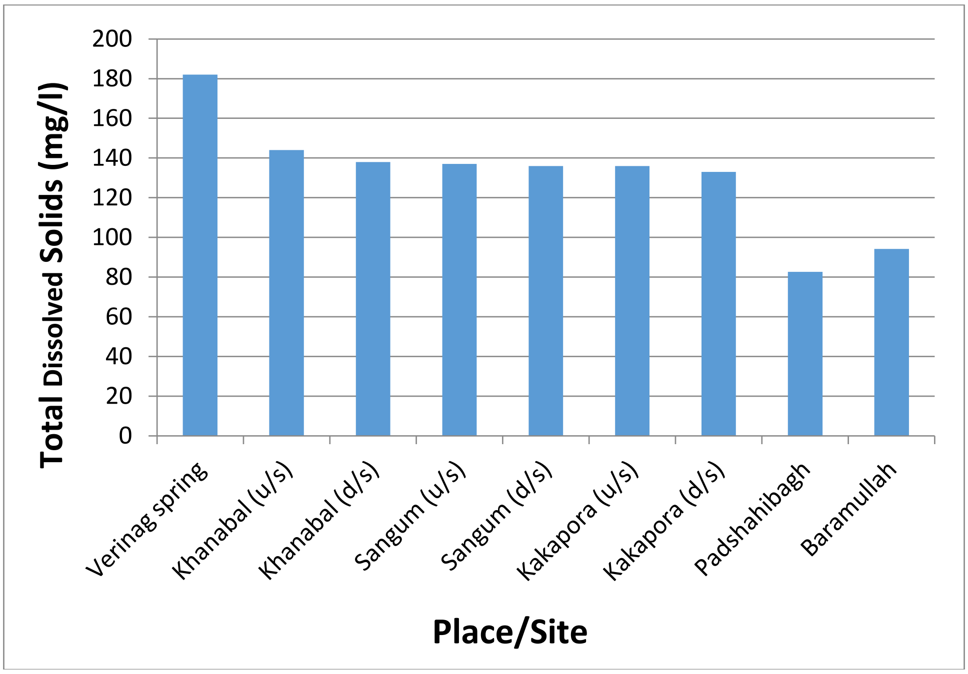

Figure 11. Variation of Total Dissolved Solids along the course of River Jhelum

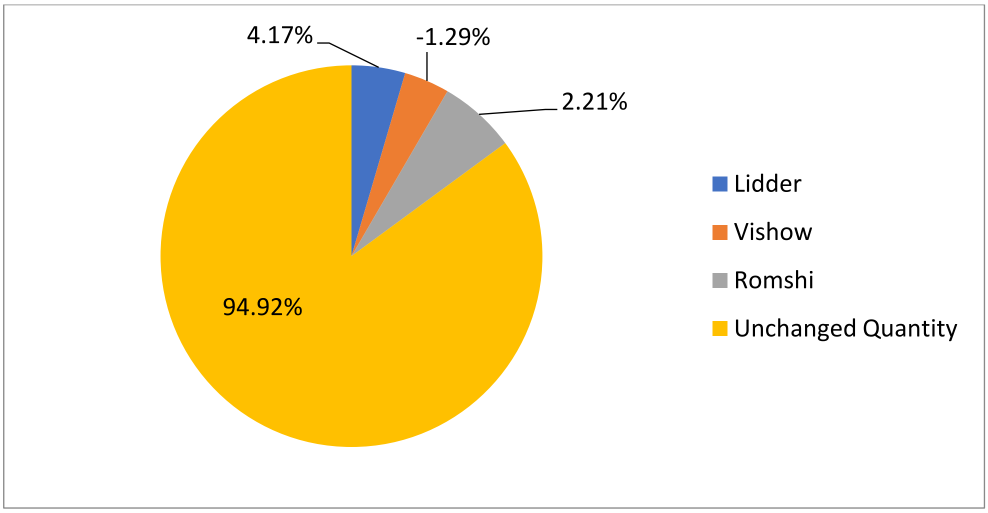

Figure 12. Relative change in TDS concentration by different tributaries of River Jhelum

Figure 13. Variation of Dissolved Oxygen content along the course of River Jhelum

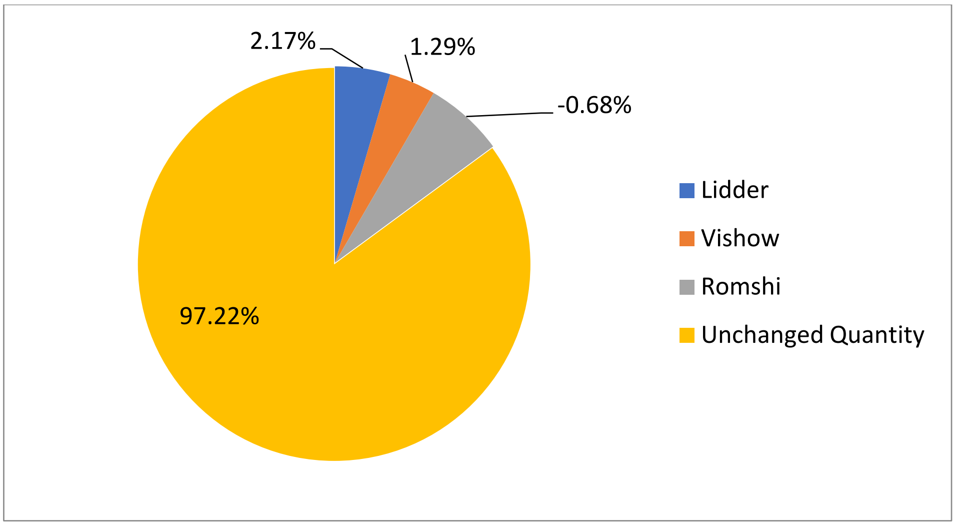

Figure 14. Relative change in Dissolved Oxygen by different tributaries of River Jhelum

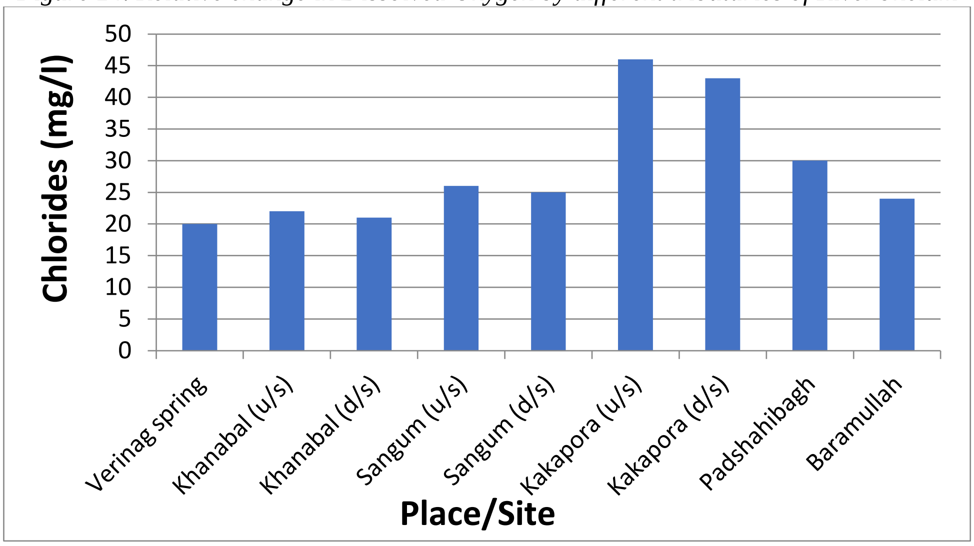

Figure 15. Variation of Chlorides along the course of River Jhelum

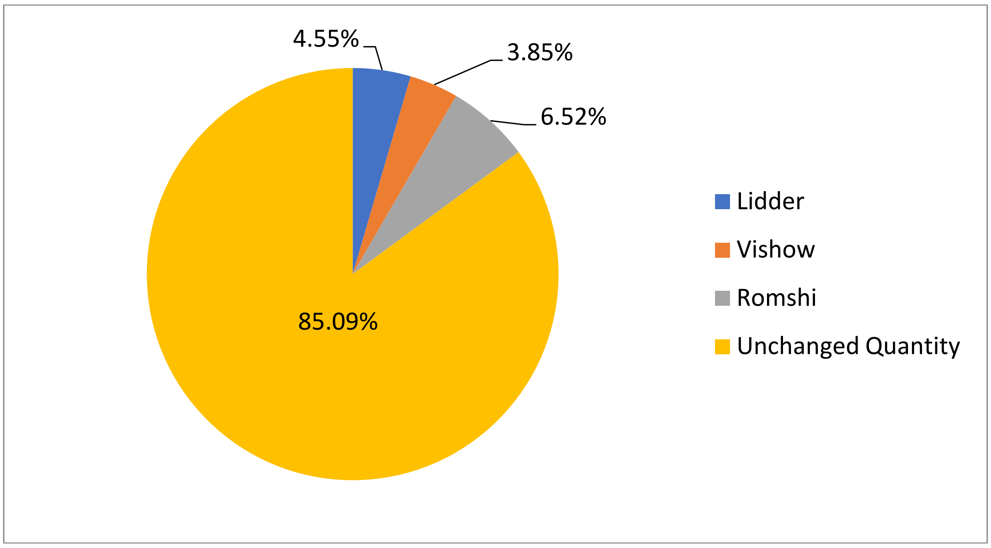

Figure 16. Relative change in Chlorides by different tributaries of River Jhelum

The variation (along the course of Jhelum River from Verinag to Baramulla) of other chemical parameters like Magnesium, Total Alkalinity, Carbon dioxide, Phosphates, Acidity, Nitrates, Fluorides and Iron, and the effect of tributaries on these parameters on Jhelum River water can be similarly presented. These chemicals also show more or less similar patterns. The reason for such variations is same as stated earlier in case of variation of physical parameters of water quality. However, there are some prominent reasons which may be attributed to unusual concentrations of some parameters e.g., alkalinity could be due to the presence of inorganic compounds; high conductivity would be caused by increased urbanization. The raised carbon dioxide content is attributed to the dispersion of carbon at the various sites of the river. The nitrate presence is due to the extensive use of fertilizers in the cultivation practices. Disposal of wastes into the river at various sites is a reason high calcium and magnesium.
The laboratory results obtained in the present study can be effectively used for controlling the deteriorating health of the river as a whole. The variations of the different parameters indicate the conservative measures to be taken which can be adopted on a regional scale depending upon the results.

IV. Conclusions

The results obtained during the study show that there is a considerable variation of physicochemical parameters of river Jhelum along its course from Verinag to Baramullah. The alkaline nature of water is attributed to the buffering properties of some inorganic substances. The increase conductivity towards downstream is due to the increased urbanization and agricultural land-use which drains into the river. The various ions added to the water from catchment areas regulate the conductivity of the water. The higher concentration of photosynthesis also has some effect on dissolved oxygen. The increasing trend of free carbon dioxide down the river is due to the addition of some carbon rich substances; majority of carbon comes from organic matter such as ground water, rock leaching, and dead terrestrial plant material. Higher concentration of nitrates is due to the excessive use of fertilizers, pesticides and addition of human excretory products. This is because of the less concentration of dissolved oxygen in lower parts of river which decreases the conversion of nitrate. High calcium concentration in the river is likely due to increased concentration of waste material especially the calcium rich substances like milk products and bones of slaughtered and killed animals. The study makes it clear that the water quality (physicochemical properties) of River Jhelum changes along its course and a severe change in certain parameters could pose a threat to the many living species by affecting directly or indirectly therefore steps must be taken to protect this divine water source which is gift of nature and the present study is a step towards the same.

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