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Assessment and Spatial Distribution of Quality of Water of the Middle Stretch of the River Jhelum using Multivariate Statistical Techniques

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A B S T R A C T

Rivers are vital freshwater system that are necessary for the continuation of life. The goal of present research was to analyze spatial dissimilarities in water quality of river Jhelum flowing through Azad Jammu and Kashmir (AJ&K). Overall, eleven water samples were collected during month of June 2014 and were examined for some physio-chemical parameters namely pH, Temperature, EC, TDS, Turbidity, flow rate, T. Hardness, Alkalinity and Salinity. The obtained results were compared with the guiding principle laid by World Health Organization (WHO) for river water quality. Only at one site "Sharda" significant amount of turbidity recorded while rest of the parameters pH, temperature, EC, TDS, T. Hardness and Alkalinity were recorded within the range of WHO guidelines.

Keywords: Water quality, Jhelum River, Multivariate Statistical Technique.

INTRODUCTION

Water is essential for all living creatures as it constitute major body part and is involve in proper cellular functioning, but unfortunately this precious and valued natural resource is under stress in term of quality and quantity (Katachalam *et al.,* 2010). About 69.99% of Earth surface is roofed with water, big water bodies like oceans and seas holds 97% of this, icecaps and glaciers contain 2.4% and (0.6%) rest of water is present in nullas, rivers, streams, ponds, and lakes wetlands. The most valued and important natural resource for living creatures in this globe is water (Vega *et al.,* 1998).

The aqueous medium present in the universe primarily have only two types, the surface water, and the ground water (Ramkumar *et al.,* 2009). The human activities and certain natural effects can change the water quality, if it is surface or ground (Stark *et al*., 2001). The navigation and other commercial activities in seas are carried out in surface water, it is also important for agriculture, animal, floral and faunal life. In developing countries is surface water is being consumed for drinking purpose and unfortunately, in these countries there is no check or monitoring on the quality of drinking water by any authority (Kowaliski *et al.,* 2006).

The river and streams water has been considered as very important tool for the forecasting of floods and aquatic resource management (Haque 2008). For the determination of aquatic environmental status of a medium viz any water body depends upon the following four factors, the biological, chemical, metrological, and physical factors (Stanitski *et al.,* 2003). Water is a vital for life, so its conservation or conservation of such natural resources is responsibility of all individuals (Jothivenkatachalam *et al.,* 2010).

The quality of such liquid can be determined or checked by simply following the water quality index (Salim *et al.,* 2009). The Eco-health and overall environmental balance are maintained by natural background situation as ecosystems are very sensitive to any alteration in physical and chemical makeup of any water body, while rest of the environment or eco-system remain unaltered (Stark *et al.,* 2000).

The riverine water quality is deteriorating due to certain anthropogenic activities and natural factors. In the cities the situation is much worst due to improper drainage systems of the cities and industries. A variety of liquid and solid waste being incorporated into the streams and riverine system (Furtado *et al.,* 1989).

In our country, this has been very easy for public. To litter and release civic waste and even human excreta into the flowing streams, like nullas, canals or rivers. Same water is also being polluted by the wild and domestic animals while using it, as during drinking water they may drop their urine or defecation directly into the water body (Jain, 2009). The major river of the globe according to recent studies are contaminated highly, which poison the surrounding ecology and pose threaten the health of the human (IPS, 1999). By using chemical and microbiological tests the pollutants of riverine system can be stopped or minimized (Chandra *et al.,* 2006).

The microbiological analysis of municipal waste has been used for the human fecal content in water samples, which is alarming for human and Eco health. Everybody have an easy and comfortable access to dispose his or her waste in surface water and due to this reason, the surface water is much polluted around the cities (Samarghanndi *et al.,* 2007). The water quality monitoring by the relevant agencies must be carried out to inform users from downstream areas and lessen health damages in the community (Srivasta *et al.,* 2011). The human beings rely majorly on water for their daily activities, so the conservation of and management of this precious and vital natural resource must be a key interest for ever one (Ullah *et al.,* 2014).

The riverine system of any country is primarily considered the lifeline of the country, so if the lifeline is facing such ruthless treatment by the local inhabitants, then rest of the eco-health would be on greater risk. The Azad Jammu and Kashmir (AJK) is a hilly terrain, stretched North to South having beautiful riverine system and situated along the major towns and cities are receiving plenty of infectious and noninfectious pollution in clouding the solid waste, which is posing serious threat to the riverine eco-system of AJK.

The present project was formulated to analyze the quality of river water, as water is primary environmental concern of the state. By analyzing the water samples from all rivers, it would be possible to portray the problems associated with this water. The spatial mechanism of analysis not only determine the single point, but it will suggest the status of riverine water from different points along different rivers throughout AJK.

MATERIALS AND METHODS

Study Area

Azad Jammu and Kashmir (AJK), commonly known as Azad Kashmir is situated in Northeast side of the Pakistan (33 º and 36 º). The size of AJ&K is 13, 297 Km^2. The height from sea level of this area is 360 m in south while in north it is approximately 6600 m. The biggest rive of the Azad Kashmir is river Jhelum, which originate from Chashma Varinag and runs throughout the Azad Kashmir and finally dispenses into the river Chenab at head Treemu District Ghang, Pakistan. In Azad Kashmir it enters in AJ&K from Chakothi passes through Hattian Bala, Ghari Dopatta, Muzaffarabad city, where another river Neelam dispense in river Jhelum at Domail Muzzaffarabad, and flowing through, Kohala and Dhan gali. At Mirpur an earthen water dam (Mangla Dam) was constructed, river Jhelum put its water in it and again through spillways and through powerhouse this river again receive water. Another River Poonch also enters in the Mangla Dam. The Mangla Dam and Reservoir irrigates about 3 million acres (1.2 million hectares) and has an installed hydroelectric capacity of some 11,000-14000 megawatts. The Upper Jhelum Canal leaves the river at Mangla and runs eastward to the Chenab River at Khanki, and the Lower Jhelum Canal starts at Rasul. Both canals are used for irrigation. The Jhelum River is believed to be the Hydaspes mentioned by Arrian (the historian for Alexander the Great) and the Bidaspes mentioned by the Egyptian geographer Ptolemy. There are ten districts namely, Bhimber, Mirpur, Kotli, Sudhnoti, Poonch, Heveli, Bagh, Muzaffarabad, Hattian Bala and Neelam in Azad Jammu and Kashmir. There are three divisions in AJ&K namely, Muzaffarabad, Poonch and Mirpur. The total area of AJK is hilly terrain comprises of undulating valleys with fast flowing river and streams. The catchment areas of AJ&K mostly receive water from rains and melting of snow. The major crops of the AJ&K are maize and wheat (Akhtar, 1999).

Field Visit / Sampling

To finalize the sampling site of the study area a preliminary survey was conducted. In this visit Neelam valley, Jhelum Valley was surveyed. A total of eleven sampling points were sampled from pre-selected areas along river Jhelum. The river Nelam, Kanhar and pooch are tributaries of river Jhelum. The selected sites were given names and codes as KEL, SHA, ATH, CHA, HAT, SUN, DAM, KOH, DAN, PAL and JHL. Polyethylene bottles pre rinsed were used by diluted NH3 acid.

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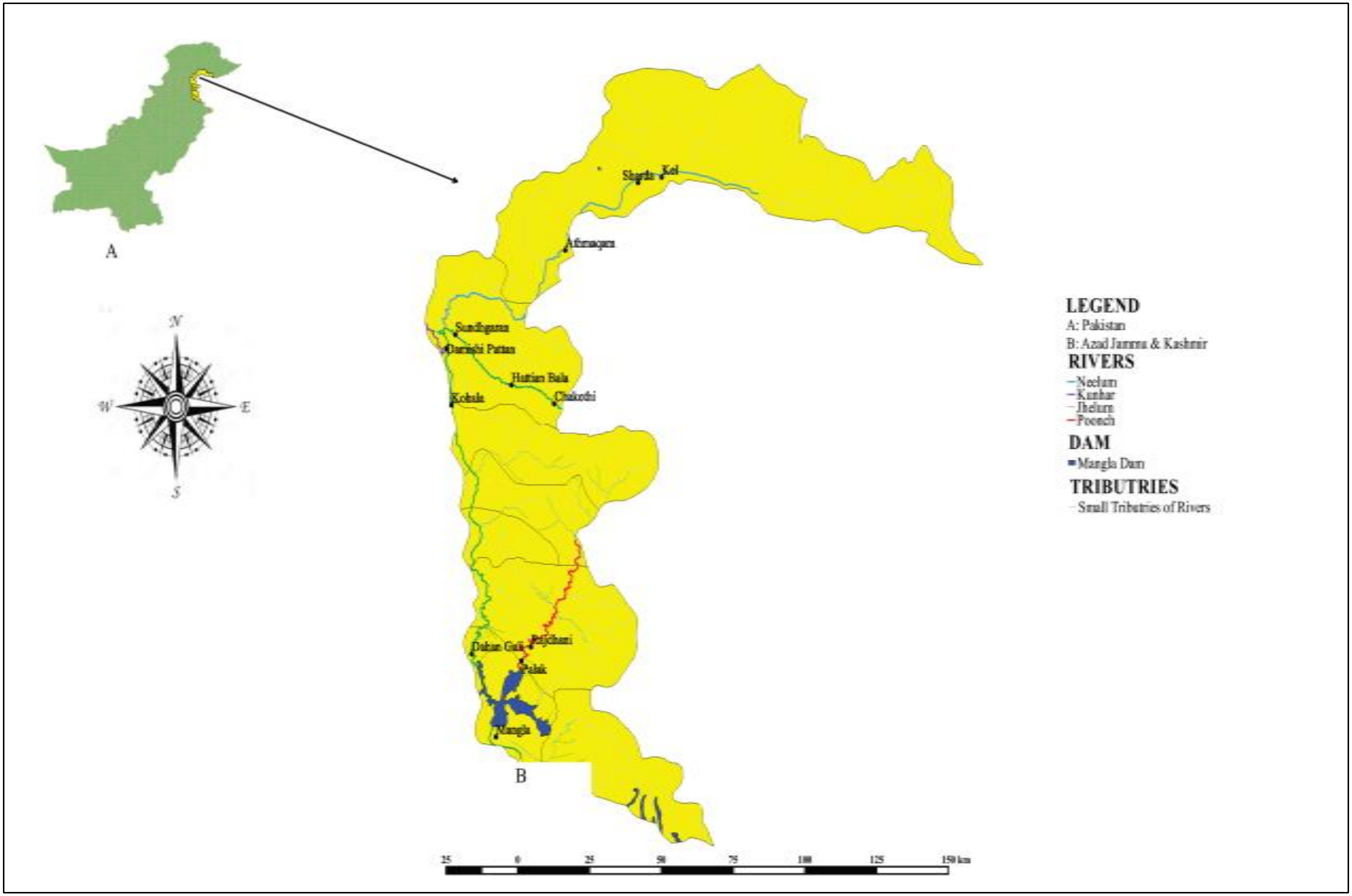

Figure-1: Map of AJK, is showing the study area.

Certain parameters viz temperature, pH, and flow rate of the river water were noted at spot. All the samples kept in laboratory at MUST, by following American Public Health Authority (APHA, 1998).

Chemical Methods

Physical Analysis

TDS, pH, temp., rate of flow of water, electrical conductivity (EC) and turbidity were noted/ calculated at each spot. Portable "WTM-82362 Weilheim" meter was used for temperature measurement on spots for all sites. A stopwatch and floating material (polystyrene cup) were involved. Polystyrene cup was released from starting end and digital timer was used to note the timing when polystyrene cup touched the end point the total time was calculated and noted. Model con 510, EC meter was used in this study for the measurement of EC. For the measurement of turbidity Model TN 100 meter was used in this study. Model cone -510 meter was used for the measurement of total dissolved solids.

Analysis (Chemical)

All the chemical parameters viz salinity, total hardness, alkalinity, and pH were done by adopting standard protocols for water analysis. By using pH meter (WTM 82362), pH was measured at all sampling points on spots. For the measurement of alkalinity following chemicals were used. Methyl orang indicator; N-HCL (0.01).

The concentrated HCl >the stock>, diluted >1000 milli liters. The prepared N HCl normality was kept 0.01. In a neat and dry conical flask 15ml water sample. To monitor the alkalinity level, the MO drops also incorporated into the conical flask. The titration method was used for the sample, which was taken drop wise N-HCl, till the color transformed to pinkish color. Then HCl checked. Following formula used to calculate alkalinity.

$CaCO_3$ mg/L = (A× Normality) of HCl × 1000 × 50 ml of sample

A = ml of HCl used with MO

Total Hardness (calcium and Magnesium)

Chemicals Required: EDTA solution and Buffer solution. The water sample was taken in a neat flask prior rinsed by distilled water. By using same pipette 1ml buffer is being added into the conical flask. Indicator Eri chrome Black T (EBT) crystalline added in conical flask to monitor the red color. All the samples were titrated with EDTA color red-blue, when drop wise EDTA was added. Finally, the level of EDTA checked.

TH as $CaCO_3$ mg/L = ml of EDTA used × 1000

Sample taken in ml

The salinity meter model Con-510 was used to measure the salinity.

Statistical Analysis

SPSS and MVSP used for the analysis of data set.

RESULTS AND DISCUSSIONS

Along the river Jhelum and its tributaries seventeen parameters including chemical and physical parameters were analyzed.

Physical Parameters

At each sampling point following parameters were checked.

Temperature

At site KEL the temperature was calculated 6.7±0.120C, at the site SHA 7.8±0.120C, at ATH 8.6±0.120C, at CHA 15.0±0.280C, at HAT 14.7±0.240C, at SUN 14.6±0.150C, at DAM 13.8±0.240C, at KOH 17.7±0.470C, at DAN 18.6±0.67 0C, RAJ 23.6±0.880C and at MNG 24.7±0.880C. Brian and Sally (2003) conducted a study on river water and suggested that anthropogenic activities are the main cause of water pollution and natural factors are also responsible for the same. Ahipathy and Puttaiah (2006) also concluded in their study that when polluted water inters in uncontaminated water bodies it may have higher temperature which can alter the temperature of uncontaminated water body. In current study significant variations are due to spatial factor for rise in temperature as study area have diversity in elevation between 320m-6000 m. The height of all sampling site gradually increases with this scheme MNG> DAN> RAJ> KOH> DAM> SUN> HAT> CHA>ATH>SHA>KEL and temperature recorded opposite to increasing trend of elevation.

Electrical Conductivity (EC)

In current study the site KEL was calculated 764.0±8.7μS/cm, at SHA 931±7.3 μS/cm, at ATH 638.0±20.1μS/cm, at CHA 658.0±8.3 μS/cm, at HAT 726.7±10.9μS/cm, at SUN 707.0±4.0 μS/cm, at DAM 760.0±4.6 μS/cm, at KOH 691.0±4.3 μS/cm, at DAN 669±12.5μS/cm, at RAJ 835.6±6.1μS/cm and at MNG 744.5±10.5 μS/cm. The maximum value of EC was noted for SHA (485 μS/cm) minimum for ATH (638.0±20.1μS). The higher value of EC value at Sharda(931±7.3 μS/cm) may be due to significant ion conc. Due to anthropogenic or natural activities and minimum due to lesser activities responsible for curtailing the level of EC in study area. A similar study was conducted by Prasad, (2005) in canal of Krishna River and found lessened conductivity.

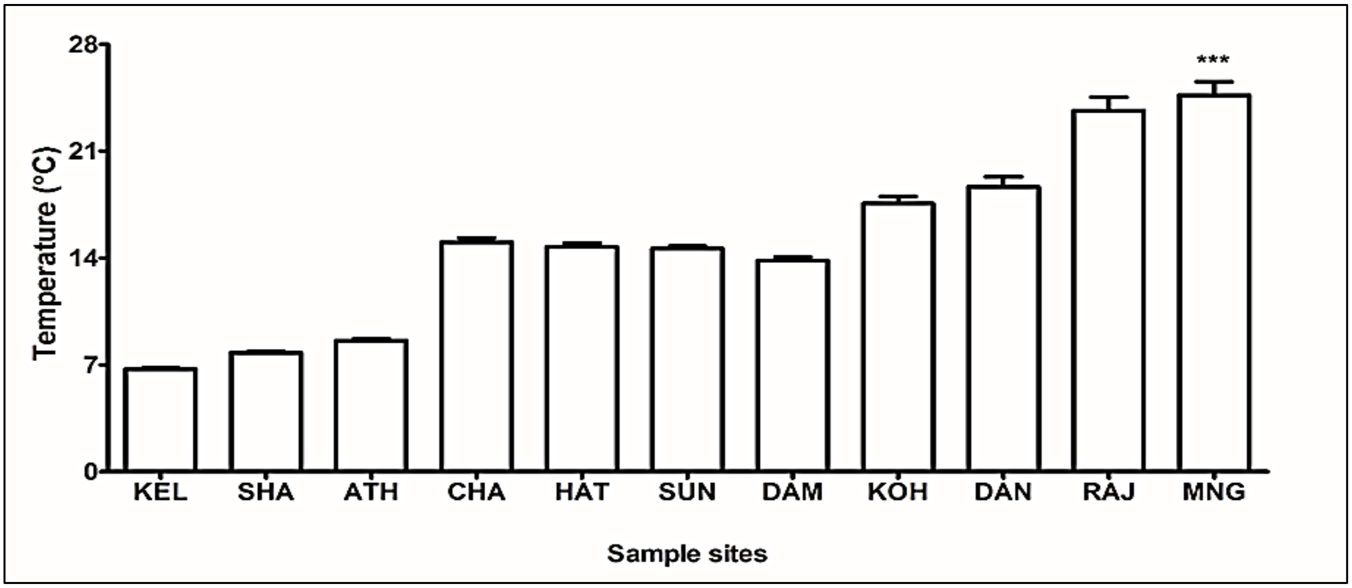

Figure 2. Temperature of water samples at various sampling sites.

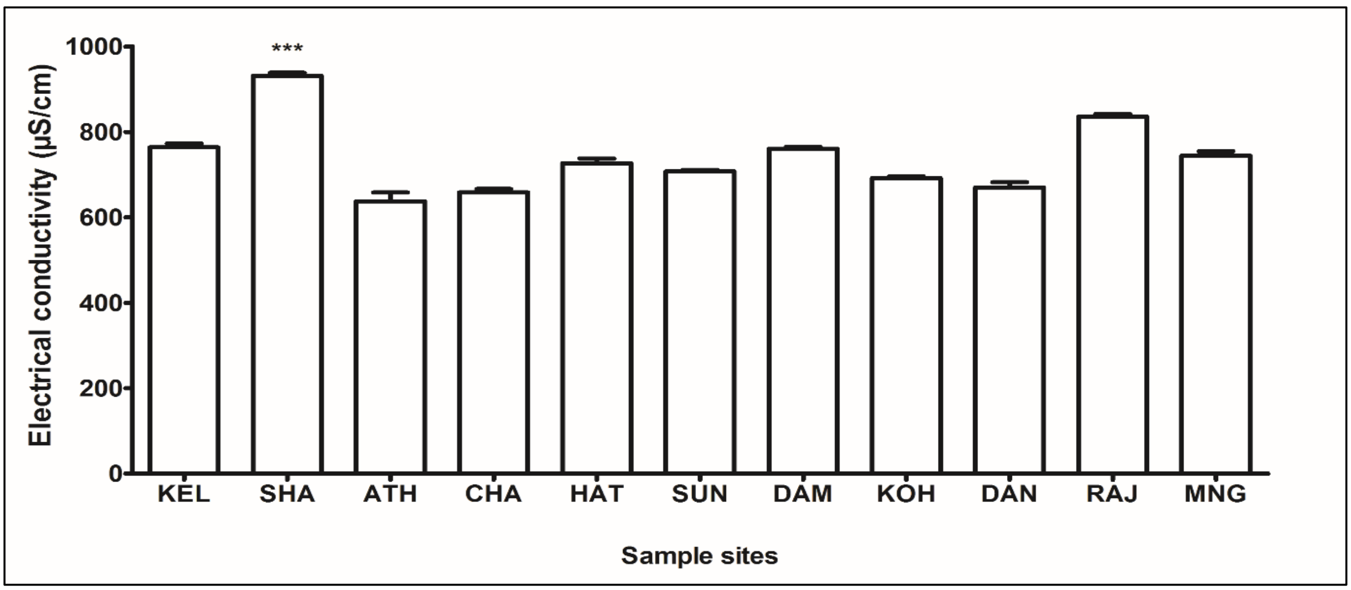

Figure 3. Electrical conductivity of water samples at various sampling sites.

The result of this study depicted those values of EC from all sampling sites is in the safe range recommended by WHO.

Turbidity

The site KEL was calculated 0.72±0.09 nephelometric turbidity unit (NTU), at SHA 5.38±0.31 at ATH 1.44±0.28, at CHA 0.55±0.07, at HAT 0.31±0.04, at SUN 0.27± 0.09, at DAM 4.95± 0.43, at KOH 2.51±0.30, at DAN 3.63± 0.19, at RAJ 0.84± 0.58 and at MNG 0.96± 0.12 NTU. Highest values of turbidity calculated for SHA site which is (5.38±0.31) and minimum at SUN (0.27± 0.09). The problem of turbidity remained dominant along the all sites but at SHA there are excavation activities and land sliding activities are being in practice, at DAM site there is joining point of river Kunhar, which incorporate turbid water in river Jhelum and increase turbidity, at KOH turbidity is higher due to land sliding and soil erosion activities at local level as at this site there is plenty of water, as the water of river Neelam and Kunhar have been dispensed before this site into the river Jhelum. So fast flowing and huge volume of water at this site cause erosion and land sliding problem which may increase turbidity problem. A similar study was also conducted by Khangembam and Gupta (2008) for river Nambul, they noted that antropogenic and natural activities were the responsible for the higher level of turbidity.

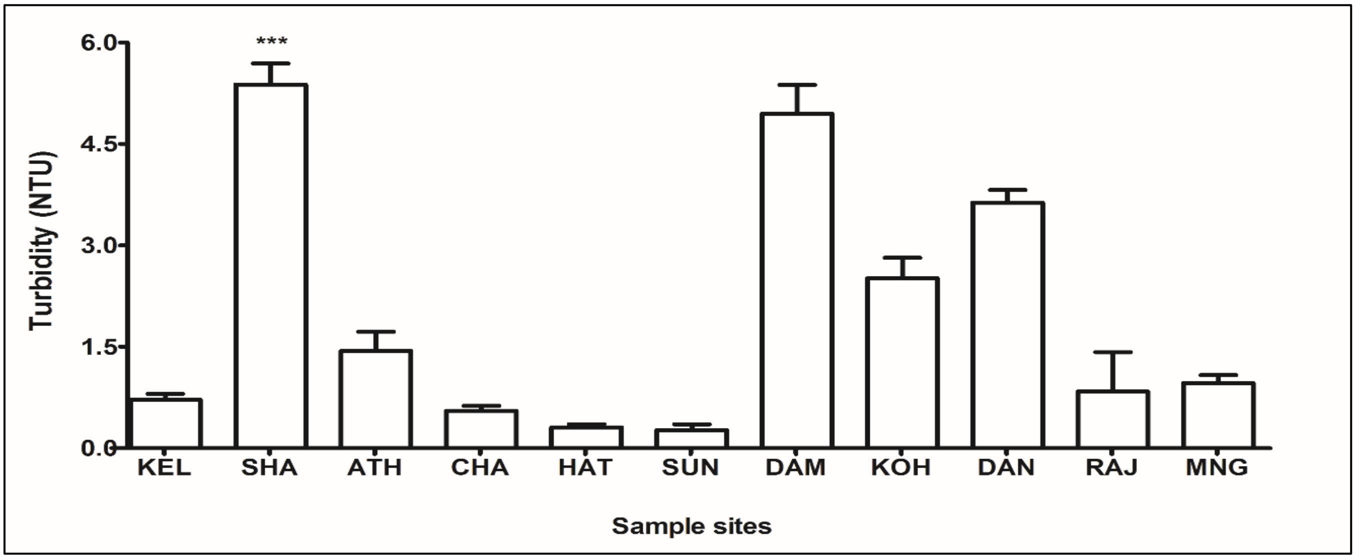

Figure 4. Turbidity of water samples at various sampling sites.

Total Dissolved Solids (TDS)

The site KEL was recorded 403.00±28.02 mg/L, at SHA 474.0±12.04 mg/L, at ATH 332±23.0 mg/L, at CHA 339.6±14.7 mg/L, at HAT 376.0±18.04 mg/L, at SUN 394.0±42.0 mg/L at DAM 423.0±45.3, at KOH 381.3±37.3, at DAN 360.6±19.7, at RAJ 447.3±32.5 mg/L and at MNG, its value was calculated 407.0±40.0 mg/L. The maximum values for were calculated for SHA site (474.0±12.04 mg/L) and the lowest at Athmuqam (332±23.0 mg/L). The maximum concentration of TDS was calculated at SHA site, this higher concentration may be due to the incorporating on carbonate and bicarbonate phosphates and other salts and fertilizers contents being used by the local farmers and residents. Some natural activities like land sliding can alsi increase this problem (Charkhabi and Sakizadeh, 2006). Mitchell and Stapp (1992) conducted a study and suggested that TDS can be increased by anthropogenic activities and this problem can harm human being as well as wildlife specially the fish, as its gills can be clogged. The overall concentration of TDS in present study remained in safe limit suggested by WHO for all sites.

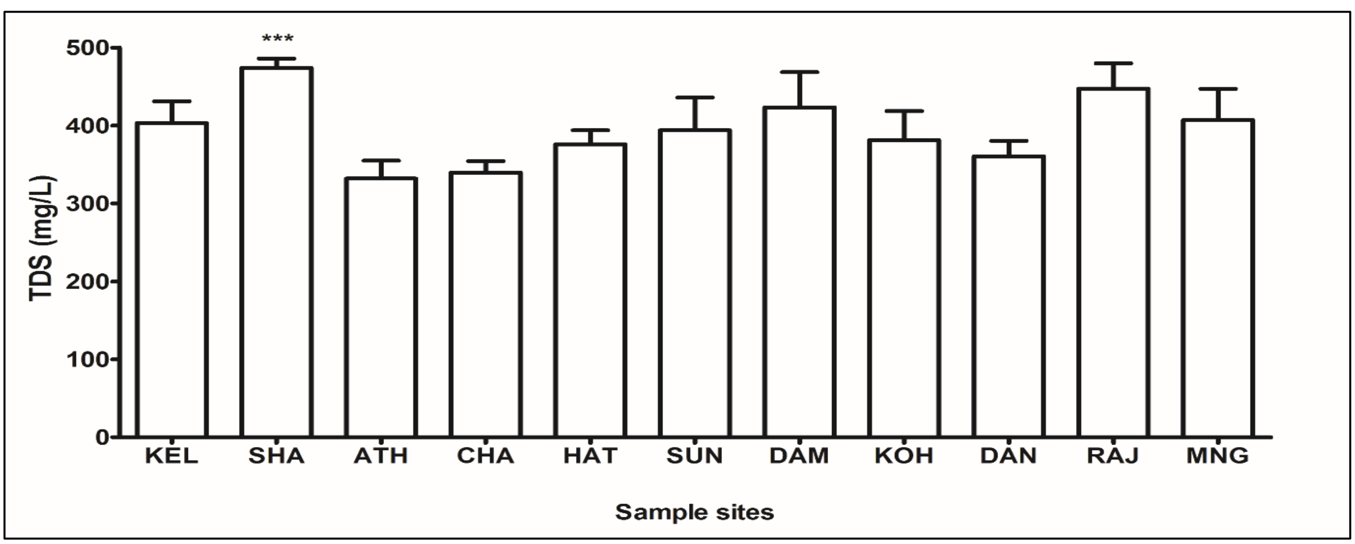

Figure 5. Total Dissolved Solids from water samples at various sampling sites.

Flow Rate

At site KEL flow rate was observed 450.0±28.8 meter per minutes (m) /min, at SHA 479.6±3.1 m/min, at ATH 450±28.8 m/min, at CHA 425±14.4 m/min, at HAT 400±28.8 m/min, at SUN 400±28.8 m/min, at DAM it was 350 ±14.4 m/min, at KOH 400±14.4 m/min, at DAN 100±14.4 m/min, at RAJ it was 150±5.7 m/min and at MNG 100±5.7 m/min. The fastest flow was calculated at SHA site, which was (479.6±3.1 m/min) while minimum at MNG (100±5.7 m/min). The flow rate has severe impact on concentration of pollutants and toxicants, if the flow is faster than there will be lesser pollution as dilution factor and aeration will be involved, while on other hand if the rate of flow of water is slow, then there will be more concentration of pollutants and toxicants as concentration will raise due to slow movement of water and it will get concentrated. There will be less incorporation of oxygen in water. Substance based on carbon can reduce pH values when water flow is higher. A same study was conducted by Poff *et al*., (2003) and they declared that running water have better water quality as compared to slow moving of stagnant.

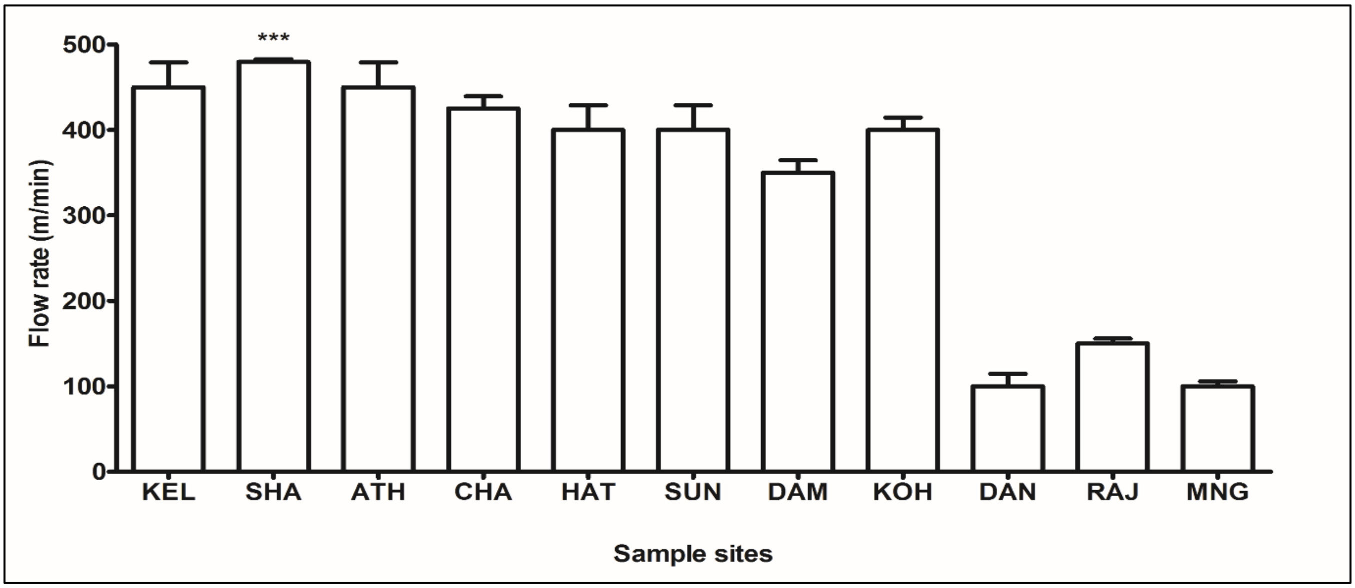

Figure 6. Flow rate of water samples at various sampling sites.

CHEMICAL PARAMETERS

pH

The site KEL was calculated 6.9±0.3, at SHA 6.5±0.3, at ATH 8.6±0.2, at CHA 7.8±0.1, at HAT 7.9±0.2, at SUN 7.09±0.2, at DAM 7.0±0.2, at KOH 7.3±0.3, at DAN it was 6.8±0.1, at RAJ 7.2±0.3 and at MNG 6.9±0.4. maximum concentration of pH was noted at ATH site which was (8.6±0.2) and minimum at Sharda (6.5±0.3) The highest pH at ATH site might be due to anthropogenic activities, like incorporation of carbonates and bicarbonates, this site also has a human population pressure, as there is Athmaqqam town having huge population, which may be responsible for the higher values of pH in this area. Sivakumar *et al*., in (2011) conducted a similar study at river Amaravathi and noted all those areas which had a human population have higher values for pH and lesser populated areas have lesser or balance pH values. Ali (1991) suggested that pH have direct impact on all living organisms. The overall results from current study depicted that all the values of pH from all sampling sites remained within the safe limits recommended by the WHO.

Hardness

At site KEL from upstream area was calculated 165±5.7 mg/L, at SHA 480±30.4 mg/L, at ATH 290±10.4 mg/L, at CHA 298.6±28.8 mg/L, at HAT 193.3±23.5mg/L, at SUN 160±20.2 mg/L, at DAM 270±20.2 mg/L, at KOH 278.3±18.5 mg/L, at DAN 280.0±10.4 mg/L, at RAJ 288.3±28.4 mg/L and at MNG it was recorded 226.6±26.8 mg/L. The maximum hardness measured at SHA site (480±30.4 mg/L) while minimum at SUN (160±20.2 mg/L). At the site SHA the higher value of total Hardness may be due to presence of certain ions viz calcium and magnesium, responsible for incensement of total hardness for this site. At this site a separate tributary dispenses in river Neelam. The name of tributary is Nullah Surghan, which is considered the biggest tributary of river Neelam in the SHA area. Beside this this site is famous for tourism point of view and a huge number of people visit this site every single day. Such tourist activities may have impact on water quality of this area. The overall results from the current study depicted that the values for hardness remained within the permissible ranges set by international agencies for water which is (500mg/L). Yousafzai *et al*., in (2010) suggested in a study conducted on river Kabul that except calcium and magnesium, sodium and potassium are also responsible for the higher levels of hardness of water.

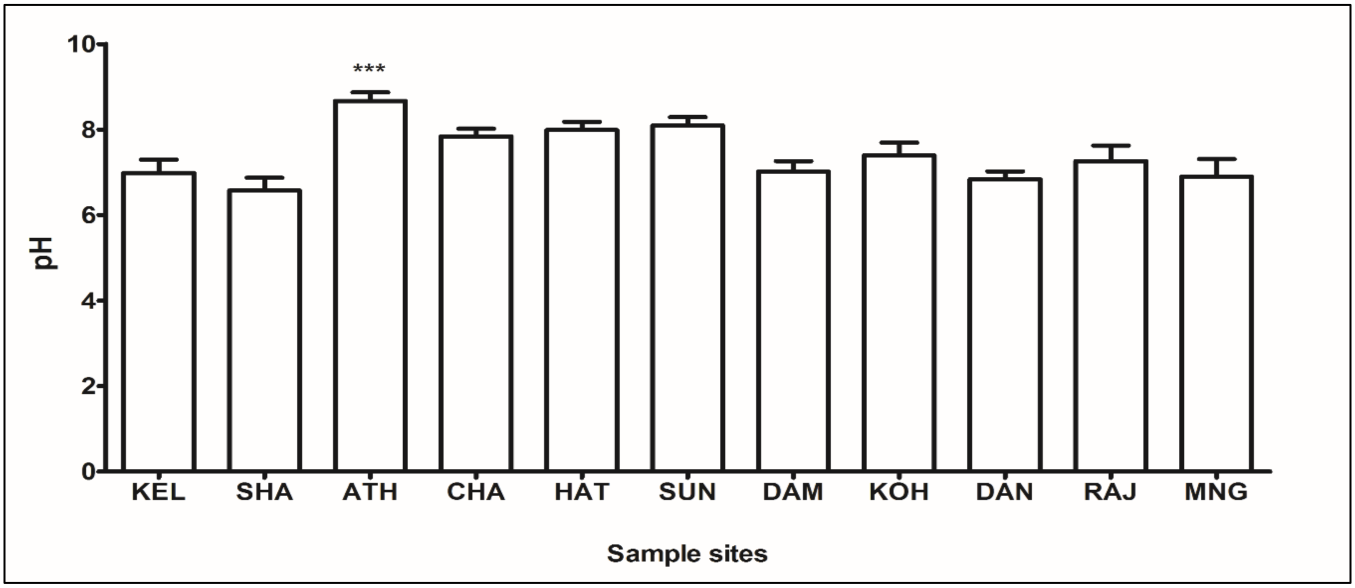

Figure 7. The pH values of water samples at various sampling sites.

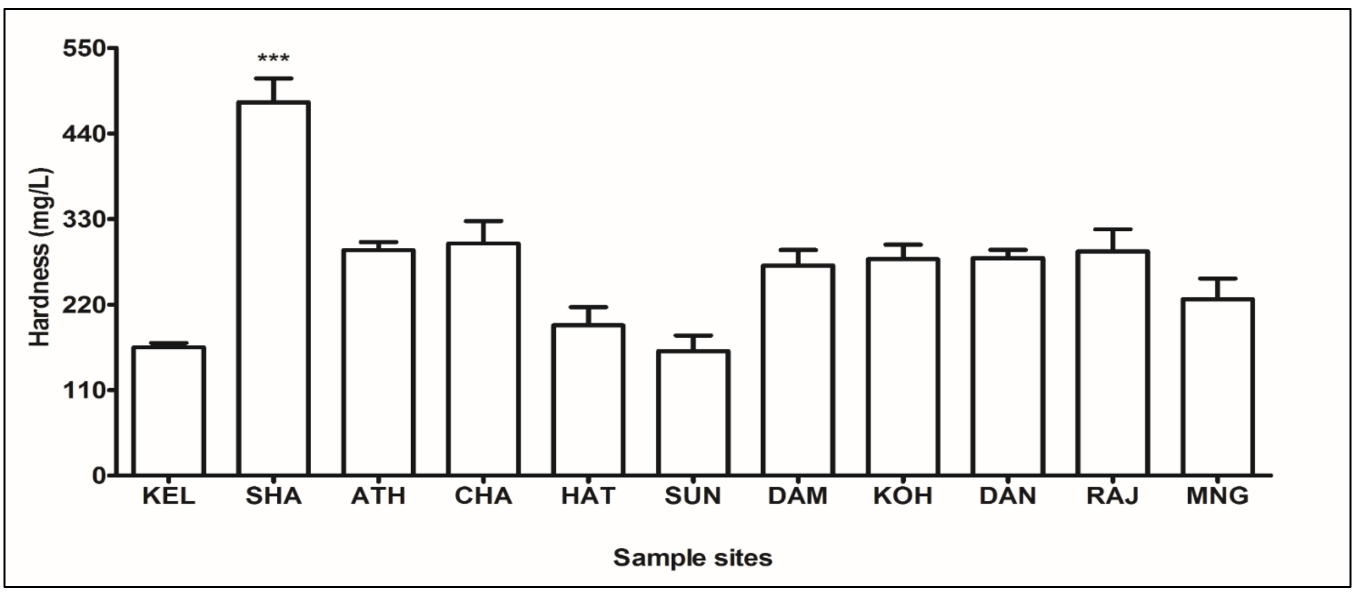

Figure 8. Harness of water samples at various sampling sites.

Alkalinity

At the site from KEL the alkalinity was calculated 212.0±9.5 mg/L, at SHA 288.3±28.4 mg/L, at ATH 235.3±10.7 mg/L, at CHA 191.6±9.1 mg/L, at HAT 185.0±2.5 mg/L, at SUN 205.3±12.8 mg/L, at DAM 190±10.0 mg/L, at KOH 174.3±11.8 mg/L, at DAN 191.3±11.3 mg/L, at RAJ 210. ±17.5 mg/L and at MNG it was calculated 184.9±7.5 mg/L. The Maximum alkalinity was observed for SHA site, which is (288.3±28.4 mg/L) while minimum for KOH site (174.3±11.8 mg/L). Like TDS and hardness alkalinity was also recorded maximum at the SHA site. This site showing maximum values for alkalinity which may be due to the anthropogenic activities being performed locally. There are certain factors at this site which may be responsible for higher concentration of alkalinity. This site is famous for tourism and a huge number of tourists visit this spot every single day, beside a separate stream locally known as Nullah Surghan also dispense in river Neelam at this site which can be responsible for higher values of certain parameters at this site including alkalinity. The overall values from all sites are still under safe limits suggested by the WHO for river water, as Azad Jammu and Kashmir is quite neat and pollution free area and have less pollution in its riverine system.

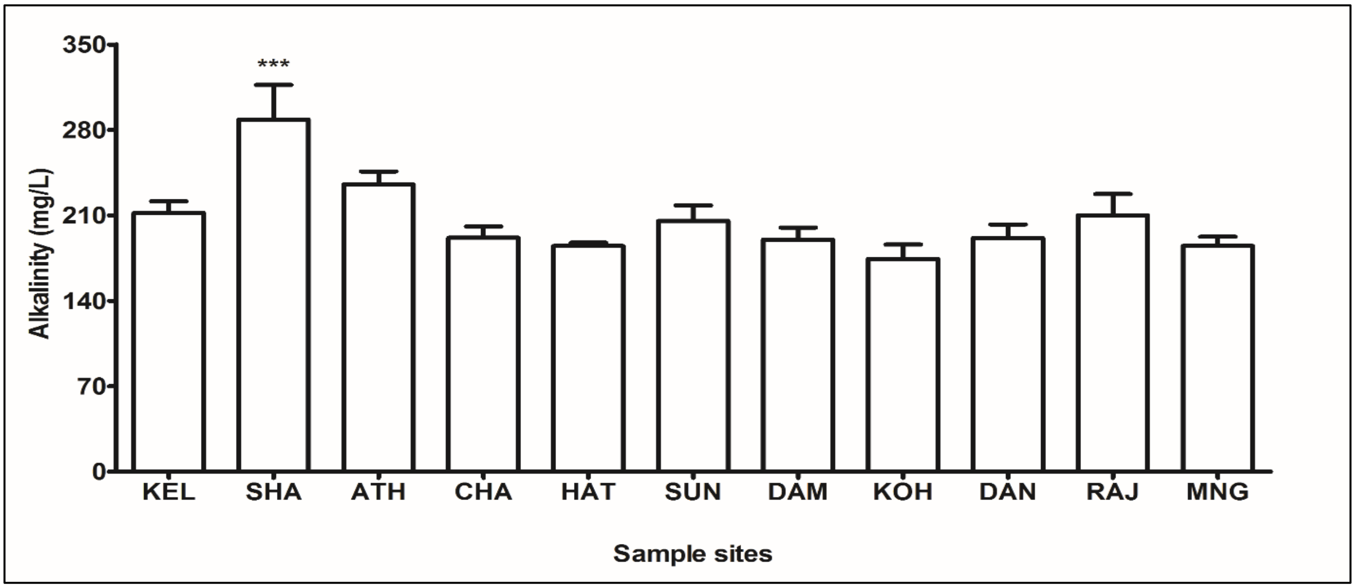

Figure 9. Alkalinity of water samples at various sampling sites.

Salinity

The results from present study depicted that the water samples from river Jhelum do not have much salt contents and there is no issue of salinity in river Jhelum. Salinity or salts contents have greater impacts on other water quality parameters, which can be altered or changed. The salinity problem is almost zero at studied sites, that's why the other parameters like total hardness, TDS, Alkalinity, and pH associated with salinity are also with in the permissible limits suggested by the WHO.

CLUSTER ANALYSIS

In (Fig. 10) all sampling sites are clustered by using Euclidian coefficient which shows the similarities among different sites, viz, SHA falls separate in the cluster, its mean it shown different behavior, so at this site there was higher turbidity due to excavation activities and land sliding. The three sites PLK, DAN and JHL are downstream area of the study area and are showing similar trends in term of variation among the different parameters, The SUN and HAT are also very closely related sites from river Jhelum and are clustered jointly. KOH, CHA and ATH are sites on river Jhelum which are showing similar behavior in term of water quality parameters as these sites are situated in almost similar area and have similar pollution and environmental problems. The KEL site is showing a separate behavior due to higher level of alkalinity in this area due to dense forest cover and anthropogenic activities.

In the (Fig. 11) very closely related parameters clustered based on similarity among the water quality parameters, SHA and KEL don't have any association or relation inn term of fluctuations in turbidity and alkalinity respectively in both areas. And rest of the sites clustered in three major groups, viz, PLK, DAN and JHL which are nearest neighbor due to similar behavior of the water quality parameters. These three sites are from a same area and have almost similar trends in parameters. In another group SUN and HAT are clustered very nearly and are showing very close relation due to similarity in water quality parameters, and these sites are from the same localities along the river Jhelum, in area of Muzaffarabad AJ&K. The third group comprises of almost four similar sites which are closely related due to similarity in water quality parameters. These sites are from the midstream area of the study area and have similar anthropogenic activities and other pollution and environmental problems. These sites are along the river Jhelum.

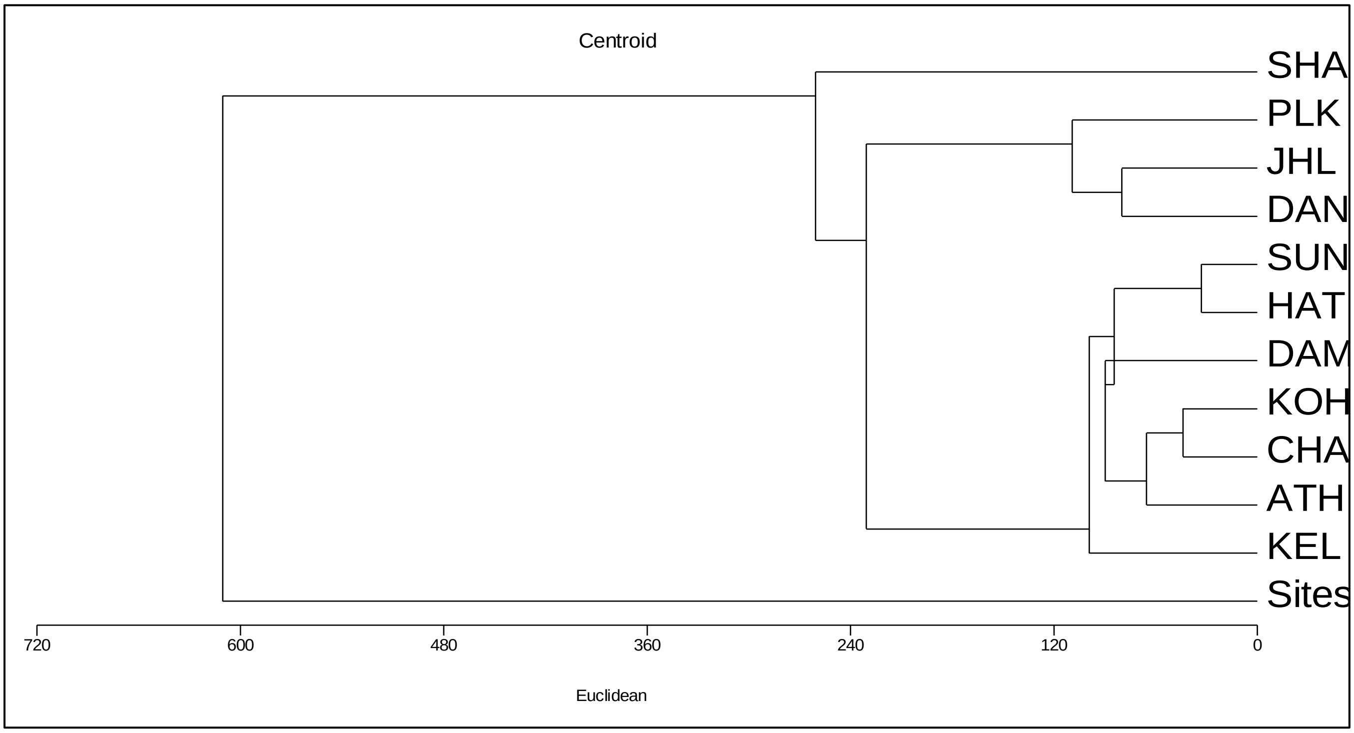

Figure 10. Cluster Analysis of All sampling sites by using Euclidian Coefficient and centroid clustering method.

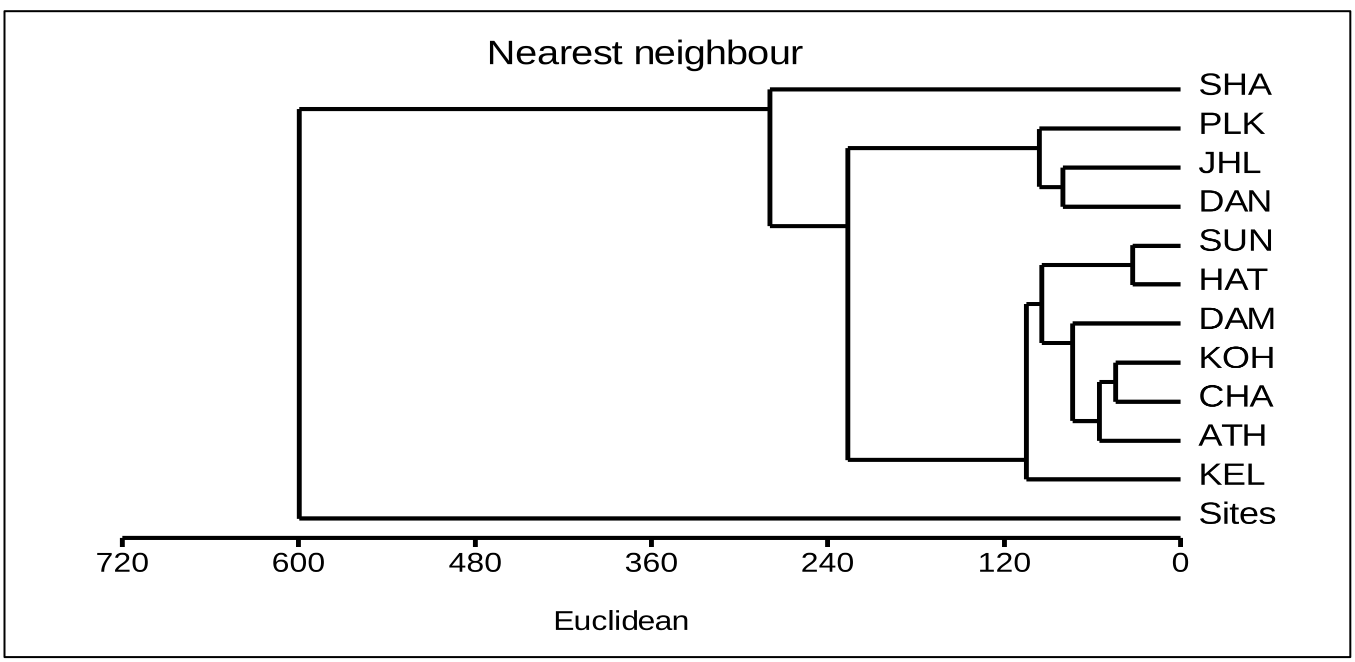

Figure 11. showing the clustering of nearest neighbor (closely related sites) by using Euclidean coefficient.

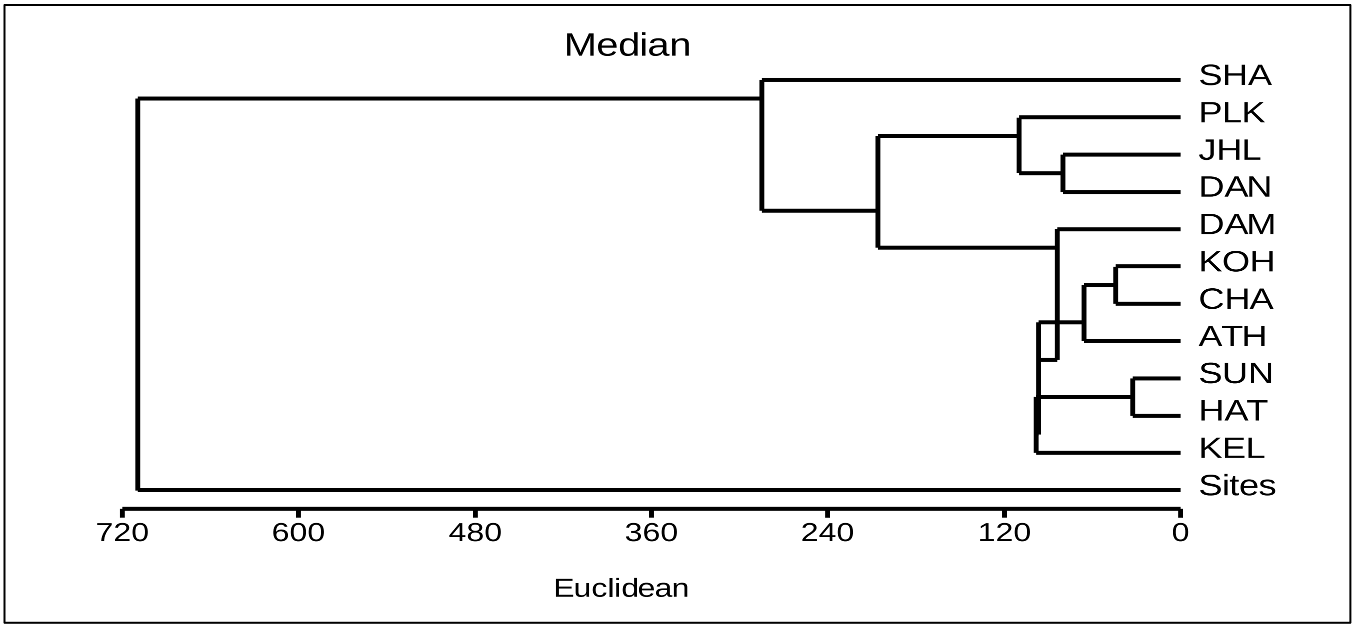

Figure 12. showing the clustering of sampling by using median and Euclidean Coefficient.

In (fig.12) site wise clustering of sites using median factor and Euclidean coefficient depicted again similar trends as discussed in finder 11 and figure 12, as certain cites have similar water quality trends and are from same region or localities which reflects the similar trends and grouped as a cluster. These sites clustered based on similarities and dissimilar sites are not grouped or clustered and remain separate as SHA and KEL due to outstanding or significant variations as compared to rest of the sites.

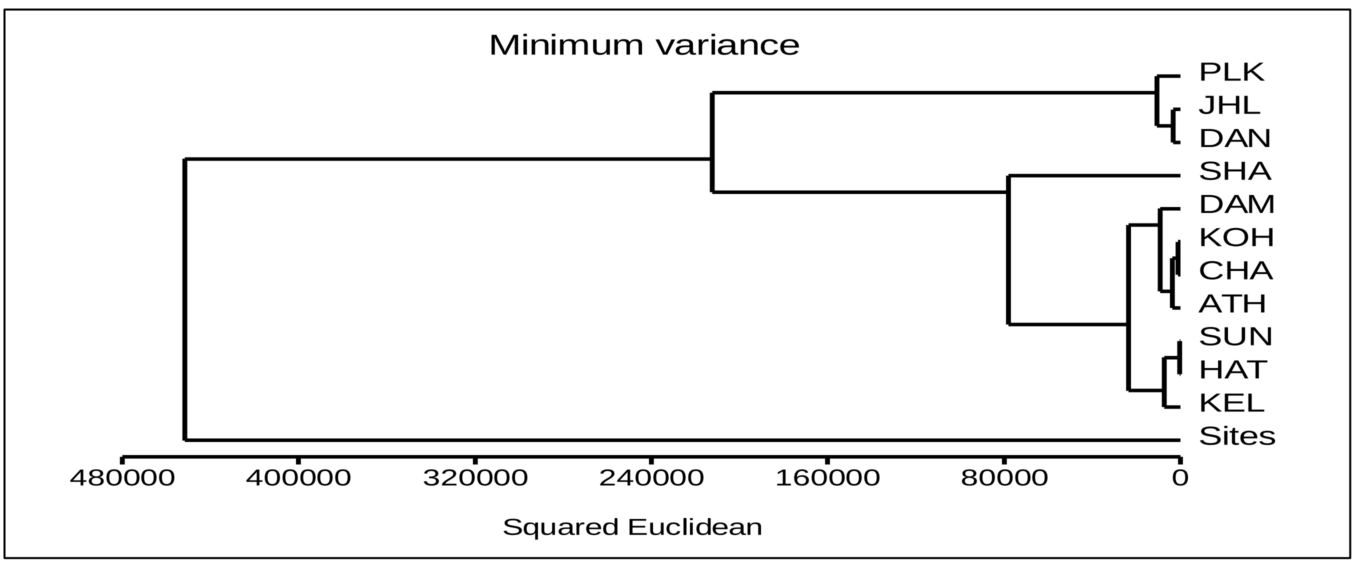

Figure 13. showing the minimum variance among the sites and their clustering Squared Euclidean coefficient.

In (fig.13) minimum variance along with Squared Euclidean coefficient was used and the sites clustered slightly different ways as compared to figures 10, 11 and 12. In this analysis the SHA site again remained separate from rest of the site due to on significantly fluctuated parameters of the water quality, but on the other hand the site KEL grouped with SUN and HAT this time. This is due to change in coefficient and variance factors which allow removal of minimum variations and allow the sites to group with nearly related or similar site. The rest of the parameters in this analysis grouped with the closely related sets as discussed in figure 10, 11 and 12.

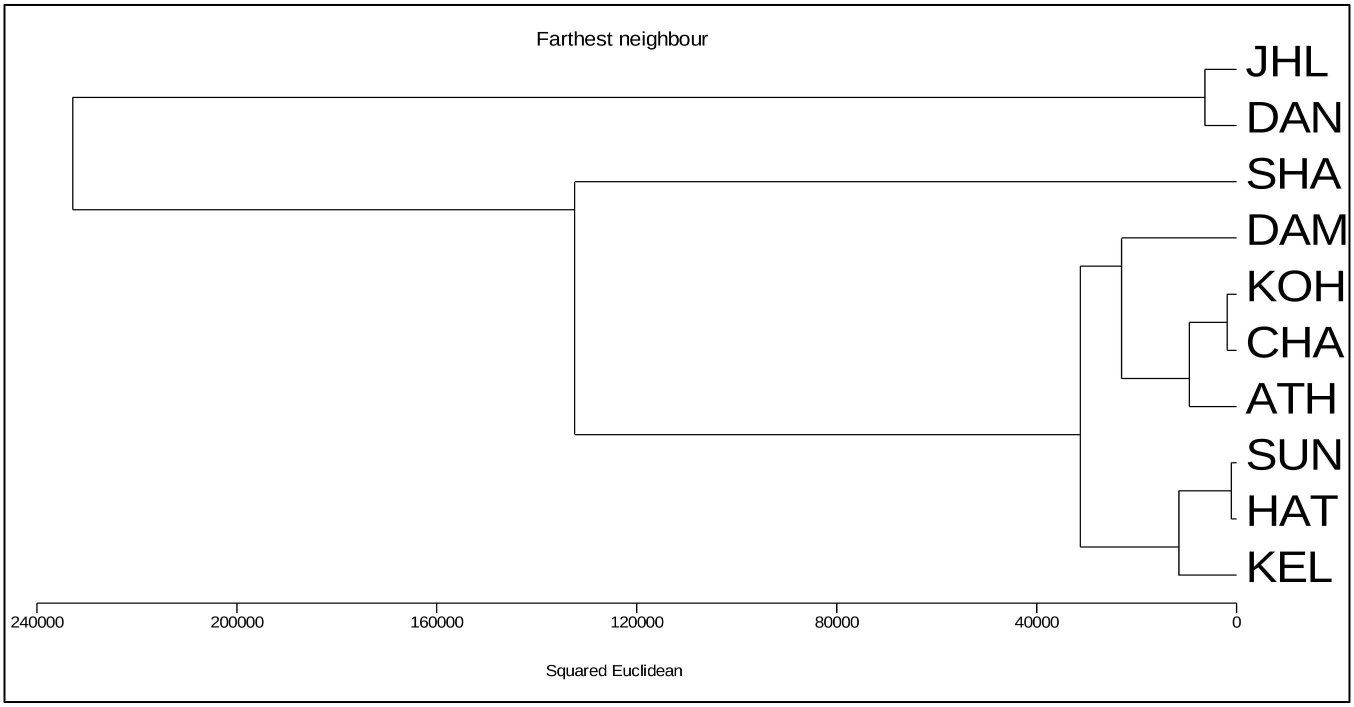

Figure 14. showing the farthest neighbor among sites and their clustering by using Squared Euclidean Coefficient.

In (fig.14) another way of similarity was checked by using farthest neighbor coupled with Squared Euclidean coefficient, these factors also show similar trends as discussed in previous figure of the cluster. The site KEL clustered with the HAT and SUN due to similarity in Alkalinity parameter of water, while SHA again remained separate due to higher levels of turbidity in the water sample due to excavation and land sliding activities being carried out and happened in the area. This factor made this site separate from rest of the sites and non-grouped even by using farthest neighbor factor.

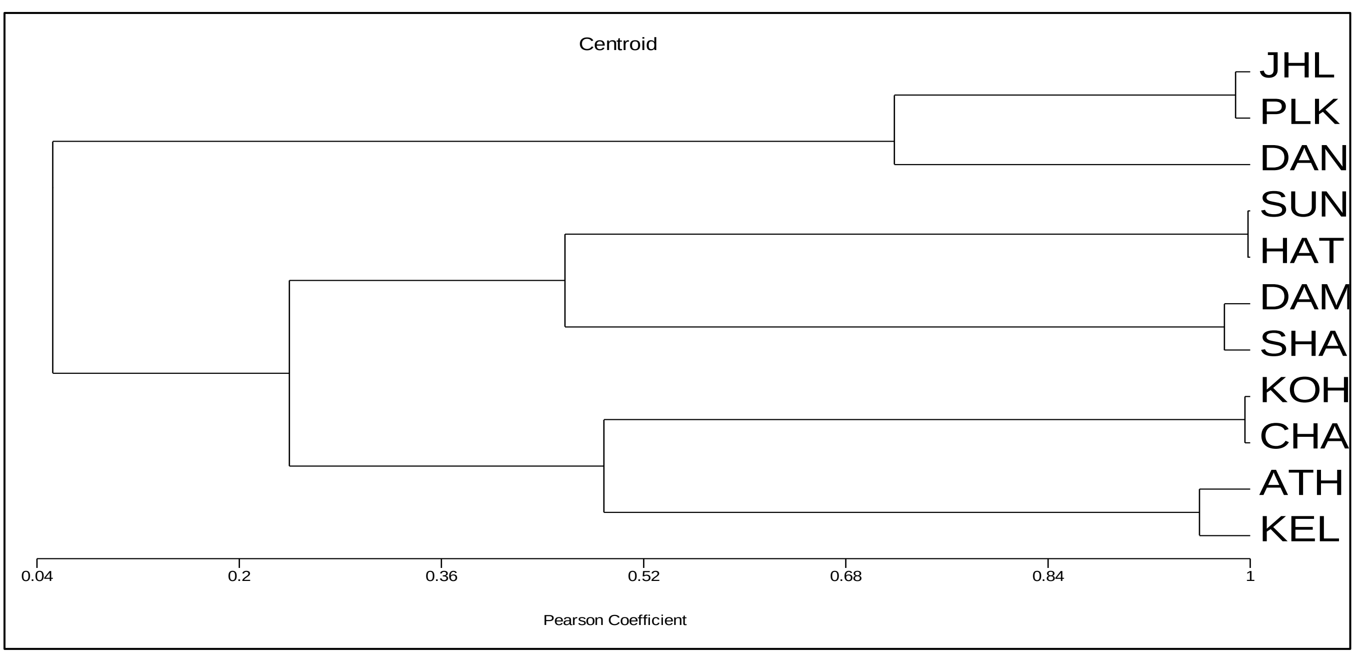

Figure 15. showing the clustering of sites as a centroid position by using Pearson Coefficient.

In the (fig.15) Centroid model coupled with Pearson coefficient was used to access the similarities among the sites. This model clustered all the sites except the DAN. This time even SHA site grouped with the DAM, but DAN remained separate. The centroid model and its coefficient identified a highly significant factor for the site of DAN, which remained separate. This separation is due to a water quality factor, which is floe rate of the water of river Jhelum at the area of Dangali, at this site the flow rate is very slow as compared to rest of the sites of the study area as at this site the water very slowly dispenses in to the Mangla Dam or the water of Mangla Dam pushes bake the coming water of river Jhelum. This factor is entirely different that's why the site DAN separated from the rest of the sites of the study area.

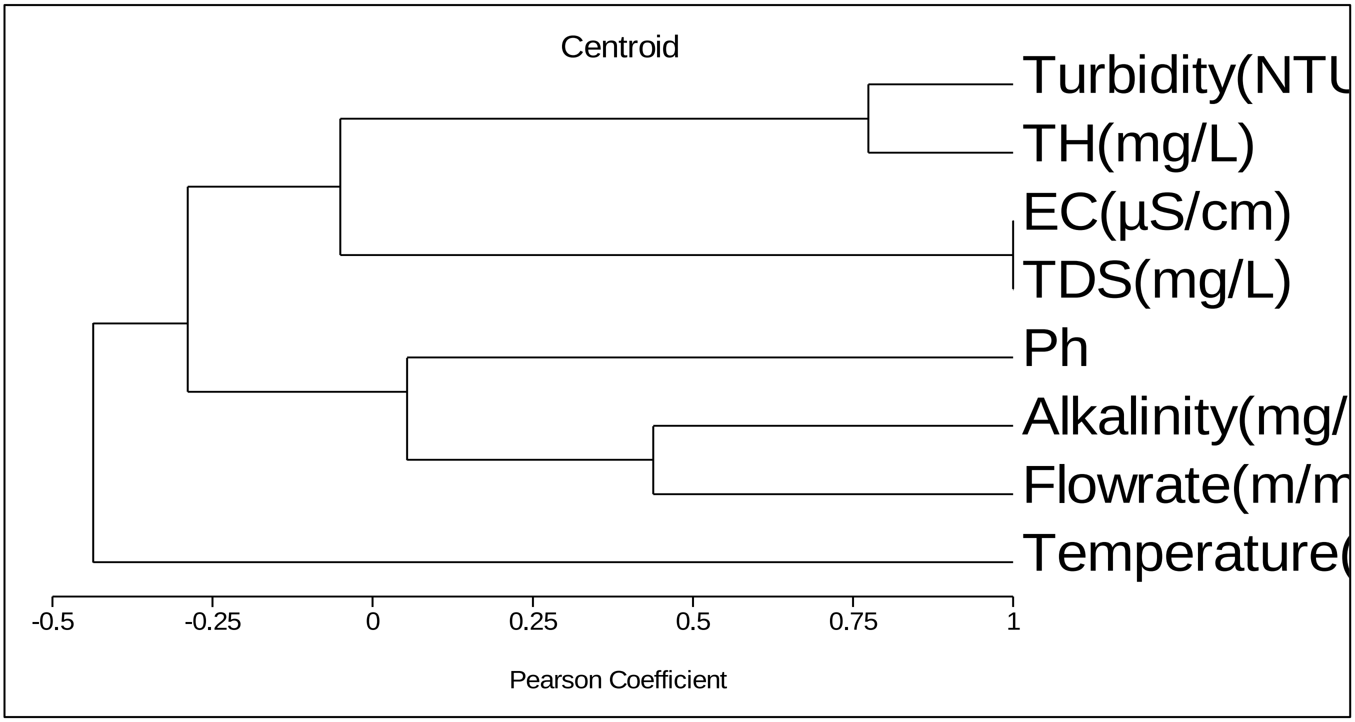

Figure 16. showing the clustering of parameters as a centroid position by using Pearson Coefficient.

In (Fig.16) different water quality parameters were clustered by using Centroid factor and Pearson coefficient. The turbidity and total hardness showed a very close relation, the EC and TDS also shoe a very close association and clustered separately. Alkalinity also show a close relation with the flow of water. Only two parameters pH and temperature showed a separate behavior and they do not cluster with the rest of the parameters. The pH is different at each site due to different pollution problems which impact the pH of the water at each site and temperature is also a critical parameter it alters with the social and temporal variations. AJ&K is a hilly terrain and have a diversified temperature of not only for water but in the atmospheric. The upstream area including Neelam valley have very less temperature and midstream areas have moderate water temperature and the downstream areas like DAN, JHL, and PLK have higher temperature of river water, even up till 22 Celsius in summer. This variation made different and clustered separately in the dendrogram.

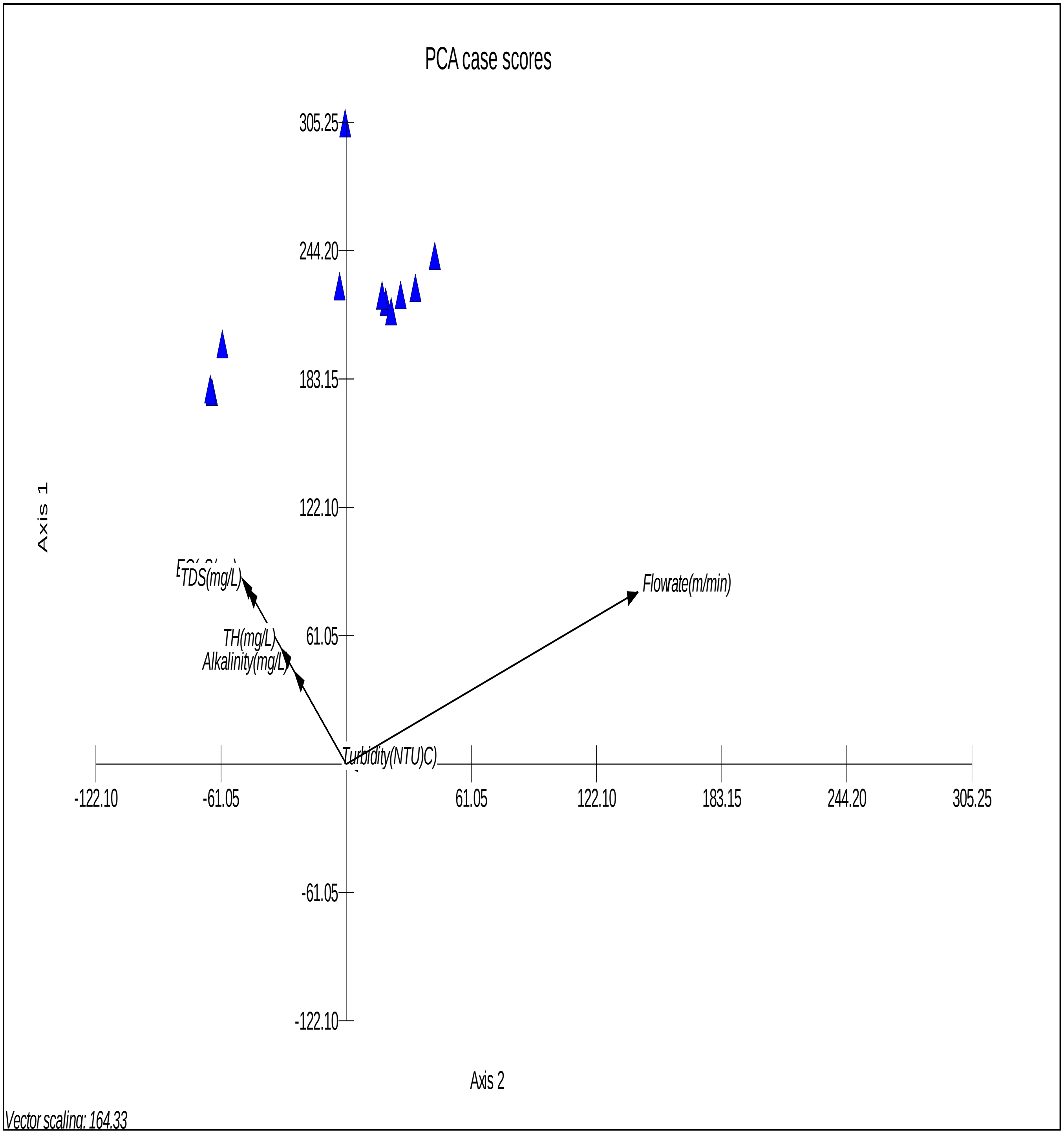

Figure 17. showing the analysis of Principal component analysis (PCA) of parameters.

To identify the grouping of similar parameters or factors which are responsible for the similarity among the sites, Principal component Analysis (PCA) was also performed. Two axes were used in this contest, and it was observed that turbidity is e central factor for similarity among all sites and flow rate is entirely diversified and go separate from groping of parameters. The certain parameters like total dissolved solids (TDS), Total hardness (TH) and electrical conductivity (EC) are grouped together, which showed a trend of similarity among all sites. In PCA analysis bi-plotting technique was used.

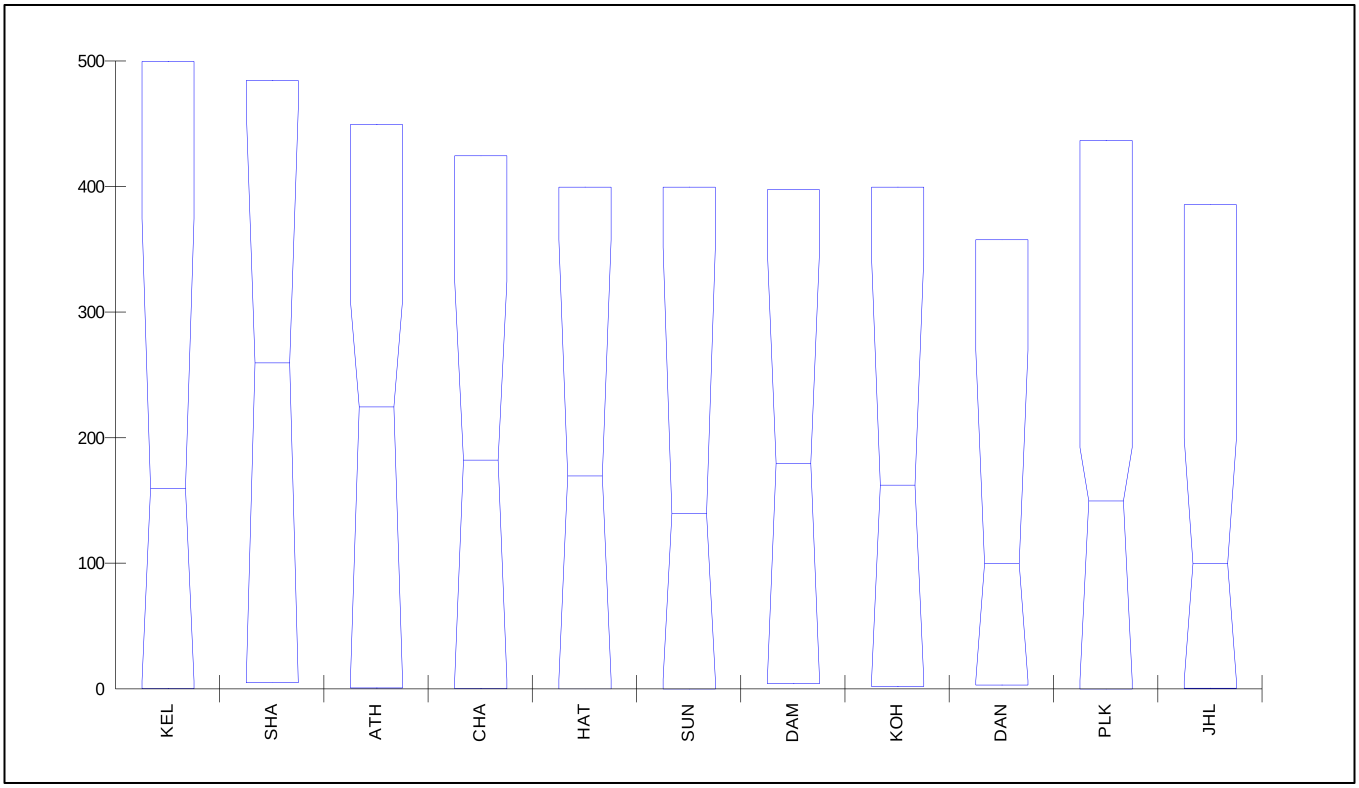

Figure 18. showing the Box and Whisker plotting of each site.

In the (fig. 18) Box and Wisker plotting also showing the variance factor among all sites.

CONCLUSIONS

A huge volume of river Jhelum flowing through AJ&K was examined thoroughly against the basic parameters of water quality and vigilant analytical approach and techniques were adopted for the attainment of better and actual status of the water of river Jhelum. All the results of physicochemical analysis were satisfactory as all the parameters remained within the guidelines laid by WHO for river water. The river water was free from salinity. Only Turbidity at (SHA) site exceeded from the permissible limit of WHO. Although its quality in general reported satisfactory in current study but its quality \ is deteriorating due to several factors; most noteworthy are developmental activities as it causes erosion and land sliding, dispensing of untreated domestic and civic wastewater and local improper agricultural activities. Hence, the water of river Jhelum cannot be used for drinking purposes without its treatment, although recreational and socioeconomic activities related to it can be performed without polluting it in state of AJK.

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APPENDIX-I

Data Related to study area (River Neelam, Jhelum, Kunhar and Poonch)

Site Name	N	E	Height mtr	Flow Rate
Kel (S 1)	34.81096	074.27547	6200	500m/min
Sharda (S 2)	34.79435	074.18788	6090	480m/min
Athmaqam (S 3)	34.58906	073.91717	5872	450m/min
Chakhothi (S 4)	34.12218	073.87609	3426	425m/min
Hattiyan Bala (S 5)	34.17889	73.71728	2915	400m/min
Sundhgaran (S 6)	34.33258	073.50839	2318	400m/min
Damishi Pattan (S 7)	34.28976	073.47428	2062	350m/min
Kohala (S 8)	34.11784	073.49434	2160	400m/min
Dahan Gali (S 9)	33.36140	073.56927	1263	100m/min
Rahdahani (S 10)	33.38240	073.78928	1300	250m/min
Palak (S 11)	33.34011	073.75431	1162	150m/min
Jhelum (S 12)	33.10876	073.65940	851	100m/min

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