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RESEARCH ARTICLE

PRE AND POST FLOOD VARIATION IN HYDROCHEMISTRY OF RIVER JHELUM DURING KASHMIR FLOODS 2014

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ABSTRACT

Flood situation (September 2014) in Jhelum River radically changed its water quality status from pre to post flood season due to both natural as well as anthropogenic sources. The aim of this study is to highlight the positive as well as negative consequences of catastrophic floods particularly the physico-chemical and heavy metal characteristics of river water. River Jhelum water samples were assessed for physico-chemical characteristics (pH, Temp. EC, Ca, Mg, N, P, K, Na, Cl and S) and heavy metal content (Cd, Cr, Cu, Ni, Fe, Pb and Zn) in pre and post flood seasons at six sites along its whole stretch from Verinag to Baramulla. Two sampling sites each were selected in three different zones of the river viz, upstream, middle stream and downstream. Results from the study provides an insight that water quality gets drastically changed in post flood seasons and most of the quality parameters of water were recorded at elevated levels in post flood seasons except a few like pH. The elevated levels of quality parameters in post flood season can be attributed to inputs from both punctual and non punctual sources.

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INTRODUCTION

The Kashmir valley was heavily impacted by catastrophic flood during September 2014. The flood not only occurred in river Jhelum, but also affected its adjoining small streams and tributaries. Flood in Kashmir watersheds can be caused by three different reasons: 1) drainage of flood from natural watershed 2) high natural runoff from a watershed during rain with high intensity and 3) combined run off from natural sources and storm sewer outlets (artificial flood). In the first case, the cause of flood is located in outside of the affected area. The flood is caused by hydrological event in an upstream section of watershed and it expands to the settlement area along the river. In the second case the flood originates directly in particular watershed, where during intensive rain event, the runoff is very high. This situation is typical for small streams and tributaries. In the third case, the flood originates directly in particular watershed and is caused by concentrated runoff from sewer system and natural run-off. The extreme flows in a river cause significant aquatic ecological disturbance which are the natural phenomena but are multiplied by human activities. The human activities like agriculture, irrigation and urbanization (incl. urban drainage) change frequency and intensity of discharges in receiving water bodies. The effect of flood can lead to hydraulic, hydrological, chemical and morphological changes of the water body (O`Reilly and Novotny, 1999). This paper presents the water quality change, which was observed before and after catastrophic natural flood in September 2014 in Jhelum River. It was observed that intense rains in the Jammu and Kashmir state from 1 to 7th September 2014 caused the floods. The causes of excessive rainfall were the combined effect of the western disturbances (WD) and their interaction with monsoon rains over Jammu & Kashmir. With the urbanized and mismanaged floodplains of Jhelum lending impetus, the situation attained disastrous dimensions. The floods directly affected more than 2,600 villages in the state and submerged 30 per cent of the urban areas. Out of the 2,600 villages, almost 400 villages were completely submerged and 2,225 partially submerged with more than 300 villages completely unreachable. In the urban areas, the water levels rose up to 20 feet whereas many villages were cut off due to destruction of the only bridges and roads leading into these villages. Local scientists had indicated in 2008 that there was a

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collapse of the natural discharge system in the valley that could prevent water from flowing out of the valley. Persistent rains for two or three days raised flood threat in Jhelum River in 2008 while as such rains wouldn't be a risk two to three decades back (Rashid and Naseem, 2008). Experts believe that the cumulative effect of the heavy rainfall event, the massive reckless urbanization of the floodplains along both sides of the Jhelum since 1972, loss of wetlands and the reduced drainage capacity of Jhelum due to the siltation from the catchment are responsible for devastating deluge (Fig. 1-5).

Fig.1-6. Glimpse of devastation caused by September floods 2014

Study Area

River Jhelum, also known as "*Vyth*" in Kashmiri language, flows a length of 203 Kilometers (km) through the Kashmir valley with a total length of 725 km in India and Pakistan. The Jhelum starts from Veirnag spring, 26 km away from Anantnag in south western region of Kashmir and moves northwestward region towards Baramulla. After leaving the Kashmir valley at Khadanyer, it joins the river Chenab in Pakistan. The river takes its name "Jhelum" from the town of "Jehlum" in Punjab (Pakistan), through which it flows. Jhelum moves through the centre of the valley. Various tributaries and nallahs of river Jhelum include Sandran, Brang, Arapat kol, Lidder, Arapal, Harwan, Sindh, Erin, Mudhumati, Pohru and Vijidakil, Vishav, Rambria, Romshi, Doodhganga, Ferozpura and Ningal. The sampling sites were selected on the basis of geography, settlements, agricultural land and commercial areas along either banks of river Jhelum (Fig.7). The sampling sites have been divided into three regions:

Upstream: [Site 1 (Chinigund Verinag), Site 2 (Zirpara Bridge Bijbehara)]

Middle Stream: [Site 3 (Zero Bridge Srinagar), Site 4 (Qamarwari Bridge Srinagar)]

Down Stream: [Site 5 (Ningli Sopore), Site 6 (Cement Bridge Baramulla)]

MATERIALS AND METHODS

Water samples were collected in replicates from each sampling site during four different seasons viz, summer (June to August), autumn (September to November), winter (December to February) and spring (March to May) from June 2014 to

March 2015. The sampling was performed in the mid month of each season on sunny days (10.30 am), when the stream flow was at normal level both in pre and post flood seasons. For physico-chemical analysis, surface water samples were collected from each selected site at 30 cm below the water surface in 1000 ml sampling bottles. For dissolved oxygen, samples were fixed with manganous sulphate and alkaline iodide in 250 ml BOD bottles in the field itself. All samples were labelled with necessary information like identification code, date, site and season and were brought to the laboratory for further analysis. All the physico-chemical parameters were analysed by fallowing standard method of APHA (2005). A volume of 500 ml water sample was collected from the depth of 30 cm and immediately transported to laboratory where the samples were filtered and then acidified with few drops of concentrated HNO_3 and was preserved in polythene bottles for subsequent heavy metal analysis using Inductively Coupled Plasma Optical Emission Spectrophotometer (Varian Vista MPX, 720). The trace elements estimated include Cu, Cr, Zn, Fe, Ni, Cd and Pb. The reagents used in the analyses were analytically ultra pure (Millipore, France). Standard solutions were prepared using Merck commercial standards for ICP-OES (Merck, Darmstadt, Germany). The accuracy of heavy metal measurement was determined on the basis of certified reference material with a recovery rate of (%): 98.4 for Cd, 98.1 for Cr, 97.8% for Cu, 97.3% for Ni, 98.4 for Pb, 98.7 for Fe and 98.1% for Zn. The statistical analysis of the data was performed in MS-Excel and Statistica v. 8.0 programmes. The obtained results were tested at 5% level of significance.

maximum value ranged from 8.6 to 8.3 mg/l in pre and post flood seasons (Fig. 11). Total Hardness values showed an abrupt change in post flood season with a value of 222.4 mg/l as against its value of 106.4 mg/l in pre flood season (Fig. 12). Sulphate concentration in water samples was found to get increased in post flood season with a maximum value of 226.4 mg/l and in pre flood season its maximum value recorded was 161.2 mg/l (Fig. 13). Fluoride and chloride values in pre and post flood seasons didn't showed much variation, maximum value for fluoride in pre flood season recorded was 0.66 mg/l and in post flood season its value was found to be 0.64 mg/l (Fig. 14). In case of chloride, the highest values in pre and post flood seasons were 22.6 mg/l and 22.7 mg/l respectively (Fig.15). Post flood season recorded more concentration of calcium and magnesium as compared to pre flood season. Calcium exhibited its maximum value of 38.2 mg/l in post flood season and 26.5 mg/l in pre flood season (Fig. 16). Magnesium reached its highest concentration of 24.04 mg/l in post flood season and showed its highest concentration of 21.91 in pre flood season (Fig. 17). Orthophosphate concentration varied from 0.3 mg/l to 0.6 mg/l in pre and post flood seasons of the study area (Fig. 18). The concentration of nitrates increased from 0.9 mg/l in pre flood seasons to 2.5 mg/l in post flood season (Fig. 19). Value of sodium concentration increased from 23.3 mg/l in pre flood season to 27.8 mg/l in post flood season (Fig. 20). Potassium concentration increased to 6.64 mg/l in post flood season as against its maximum value of 2.76 mg/l in pre flood season (Fig. 21). September 2014 floods have completely changed the

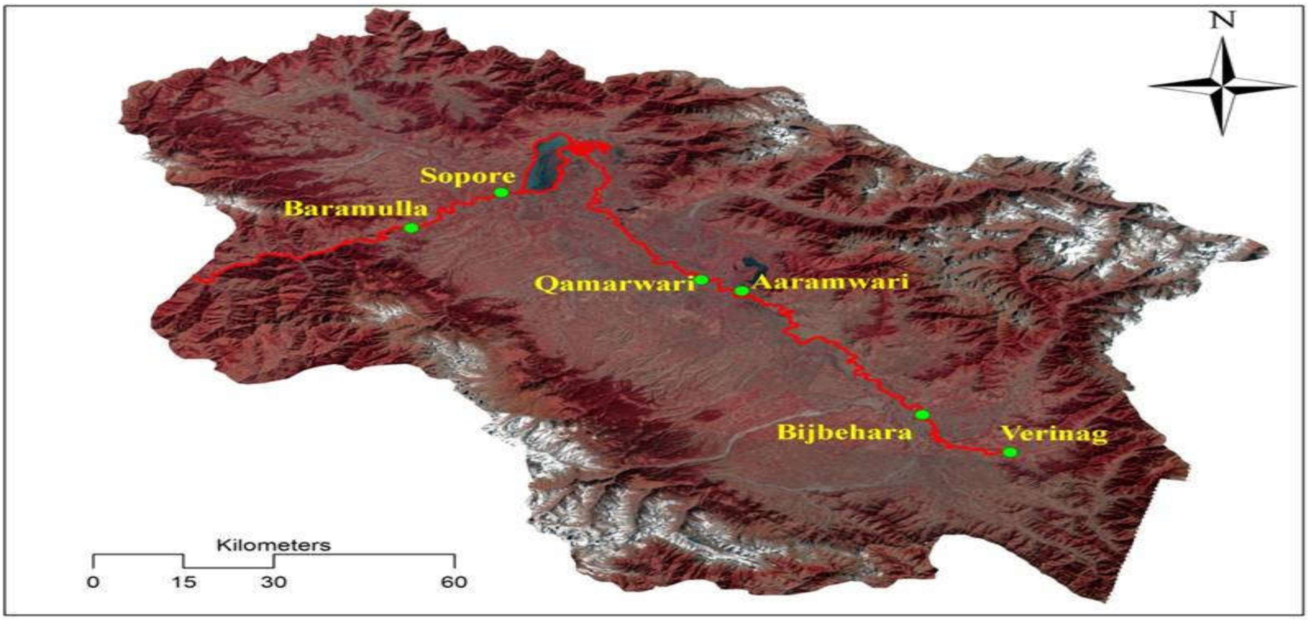
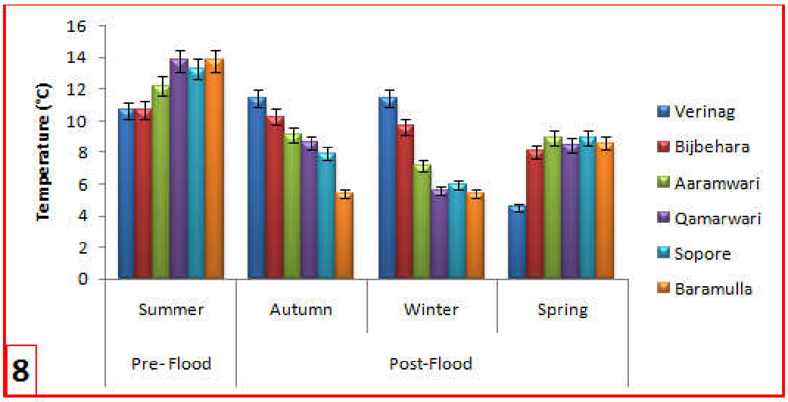


Fig.7. Study area map showing sampling sites

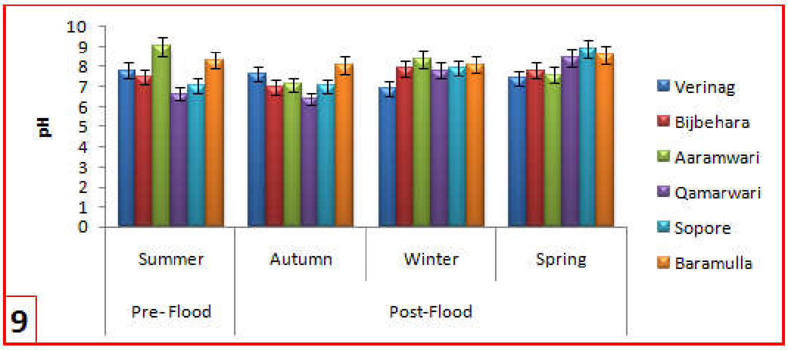
water quality of Jhelum and most of the physico-chemical parameters like pH, EC, Ca, Mg, Na, K, orthophosphates, total harness, sulphates and nitrates were found to get increased in post flood season (autumn) and again started returning to their normal values in winter and spring seasons. Simultaneously parameters like dissolved oxygen and chloride did not showed much variation and parameters like temperature, fluoride and pH have showed a decline in values in post flood season. The reason for increased concentrations in few parameters might be due to due to the inputs of water drained out from settlements, dump sites, commercial and agricultural areas during floods and decline in concentration of few parameters may be due to dilution phenomena.

RESULTS AND DISCUSSION

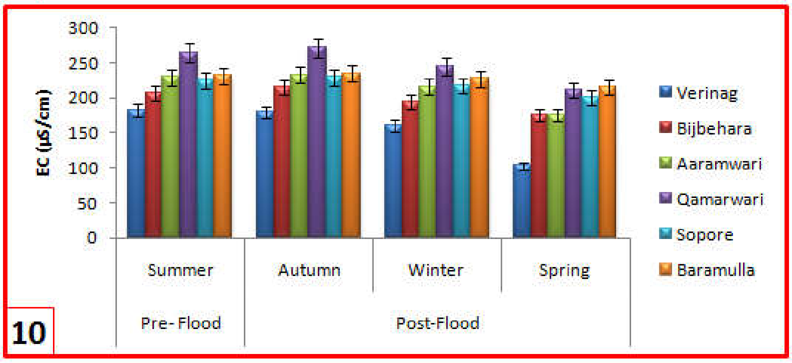
During pre flood season, highest water temperature recorded was 13.8 ºC and in case of post flood season the maximum temperature recorded was 11.4 ºC (Fig. 8). The pH of Jhelum river water reached maximum in pre-flood season with a value of 9.0 and decreased to a maximum value of 8.08 in post flood season of the study area (Fig. 9). Electrical conductivity values were found to get increased in post flood season with a value of 271.2 µS/cm as against its value of 264.6 µS/cm in pre flood season (Fig. 10). The dissolved oxygen concentration didn't show much deflection in pre and post flood seasons. Its


Temperature (°C)
0
2
4
6
8
10
12
14
16
Summer
Autumn
Winter
Spring
Pre-Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

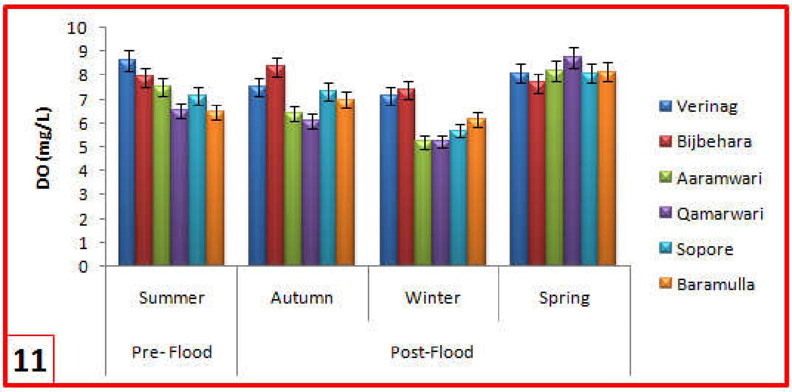
8


pH
0
1
2
3
4
5
6
7
8
9
10
Summer
Autumn
Winter
Spring
Pre-Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

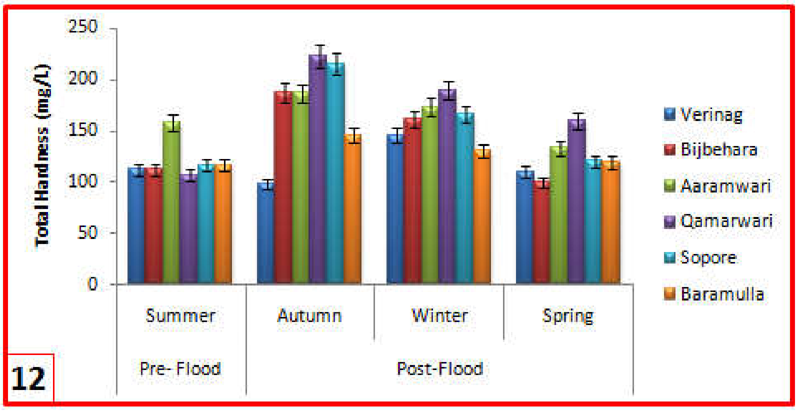
9


EC (µS/cm)
0
50
100
150
200
250
300
Summer
Autumn
Winter
Spring
Pre-Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

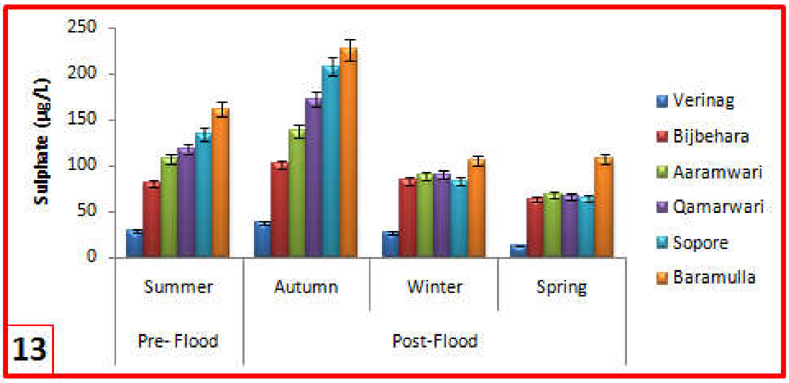
10


DO (mg/L)
0
1
2
3
4
5
6
7
8
9
10
Summer
Autumn
Winter
Spring
Pre-Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

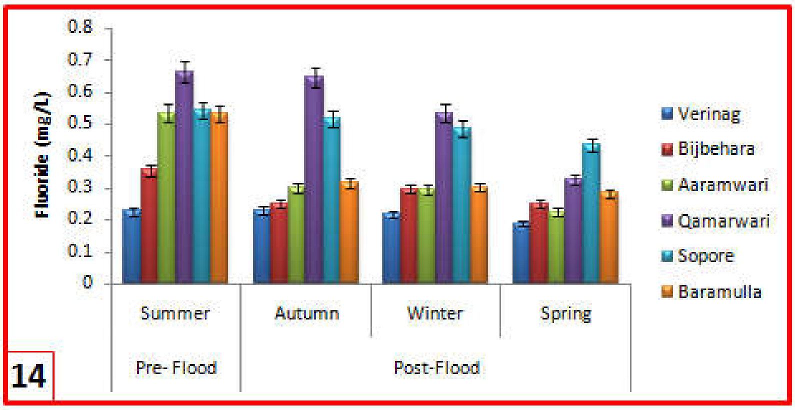
11


Total Hardness (mg/L)
0
50
100
150
200
250
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

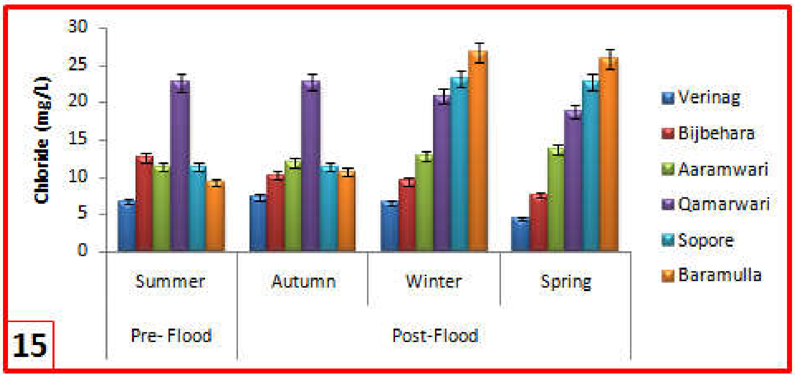
12


Sulphate (µg/L)
250
200
150
100
50
0
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

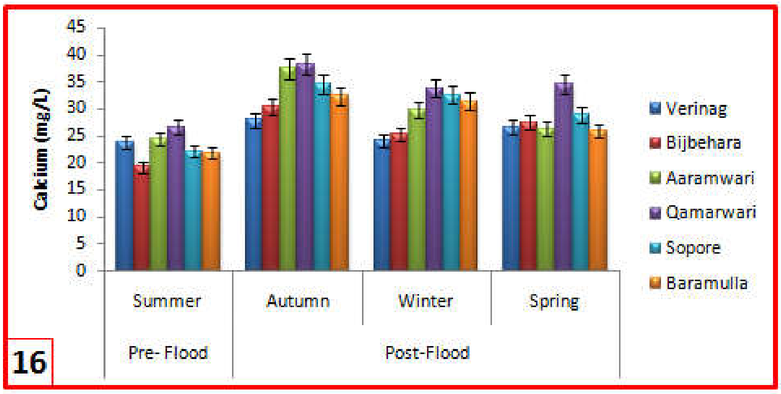
13


Fluoride (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

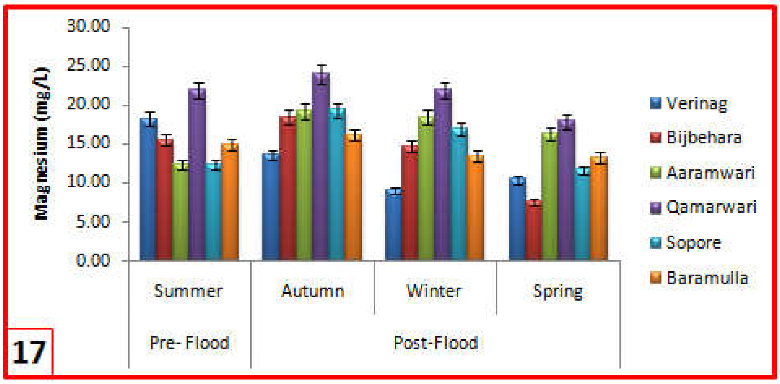
14


Chloride (mg/L)
30
25
20
15
10
5
0
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

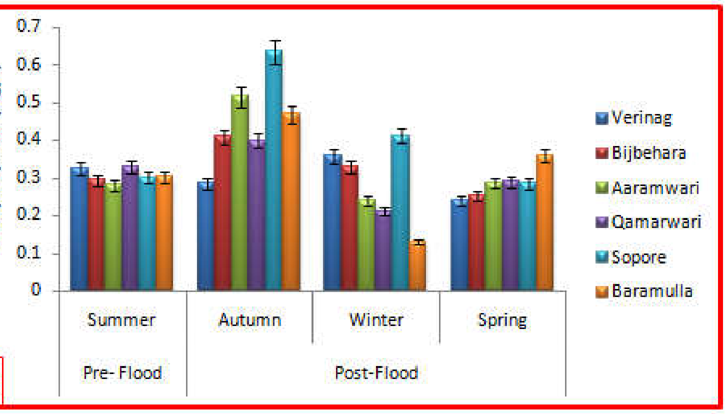
15


Calcium (mg/L)
45
40
35
30
25
20
15
10
5
0
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

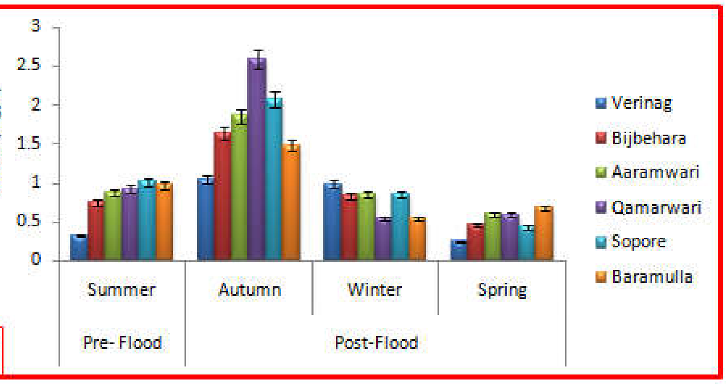
16


Magnesium (mg/L)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

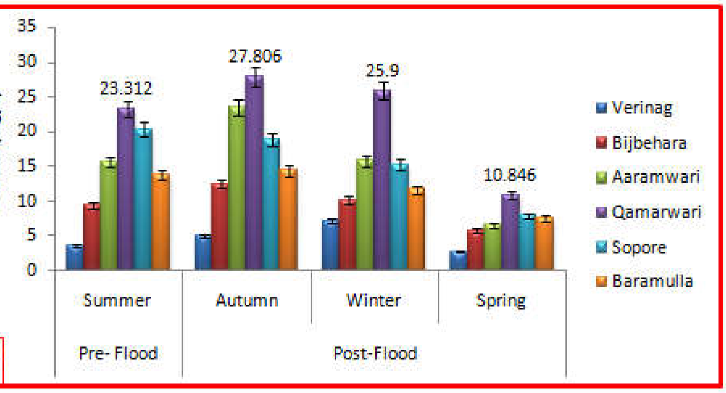
17


Orthophosphate (mg/L)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

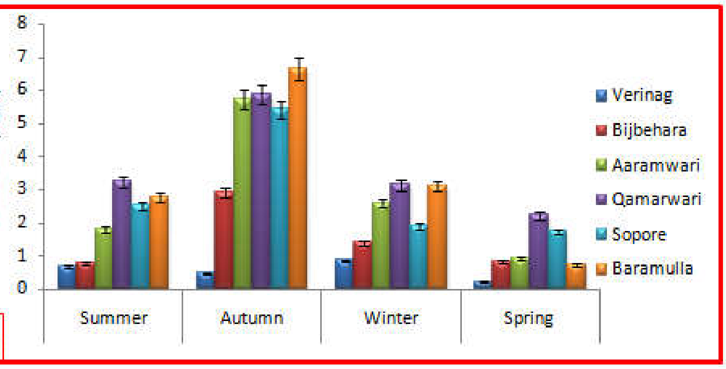
18


Nitrate (mg/L)
0 0.5 1 1.5 2 2.5 3
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

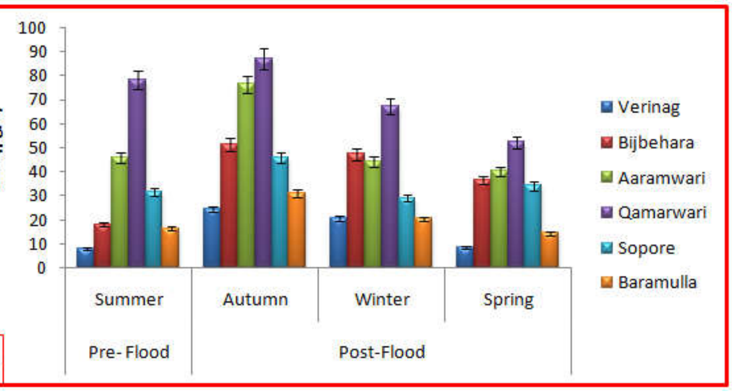
19


Sodium (mg/L)
0 5 10 15 20 25 30 35
23.312
27.806
25.9
10.846
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

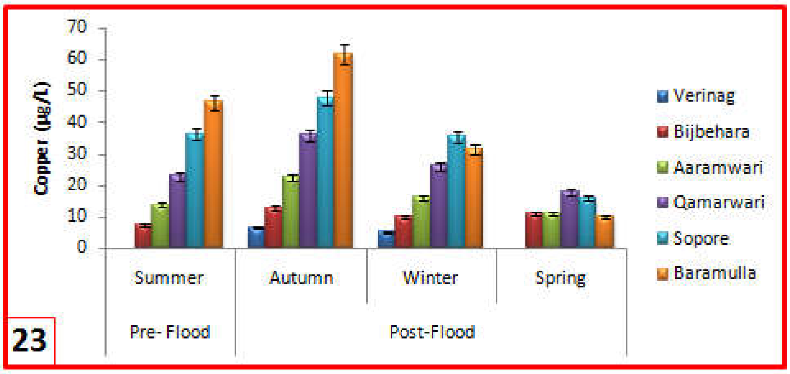
20

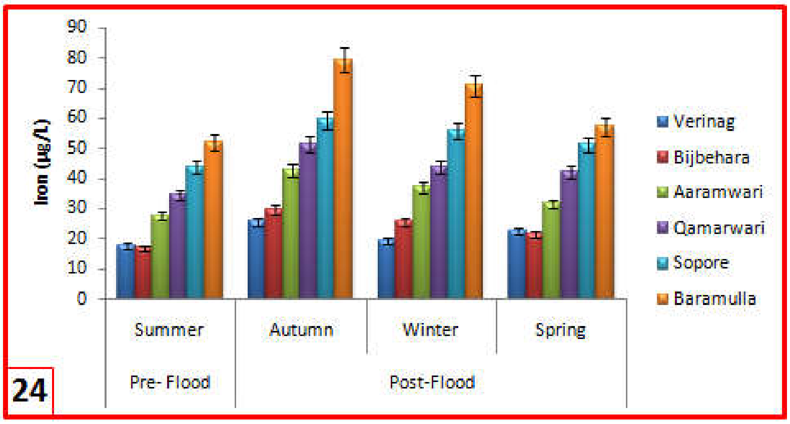

Potassium (mg/L)
0 1 2 3 4 5 6 7 8
Summer
Autumn
Winter
Spring
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

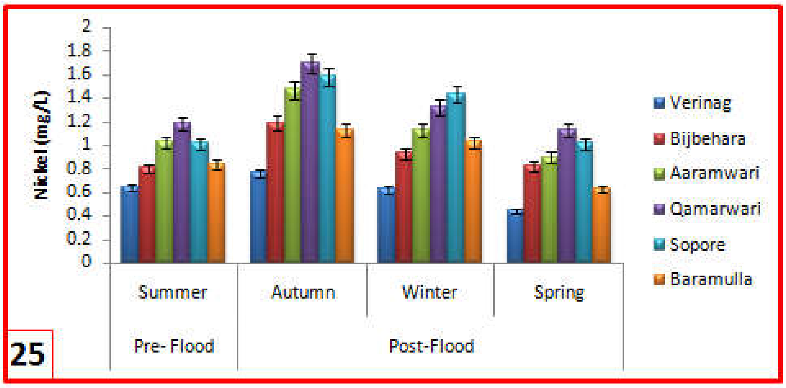
21

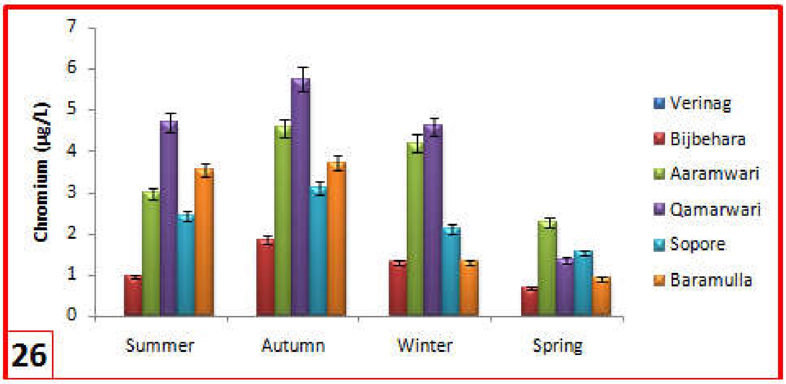

Zinc (µg/L)
0 10 20 30 40 50 60 70 80 90 100
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla

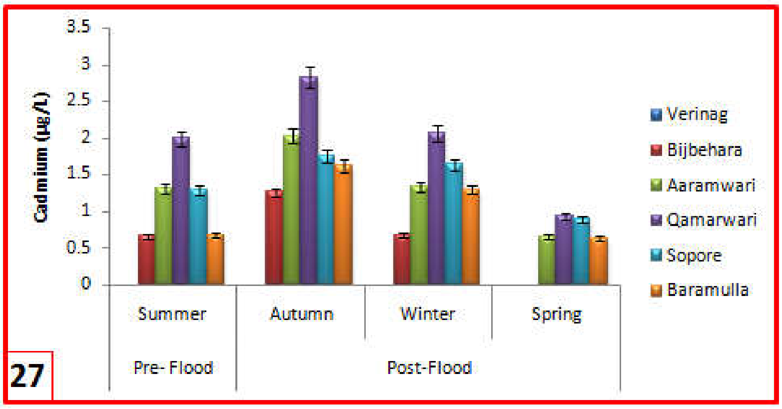
22

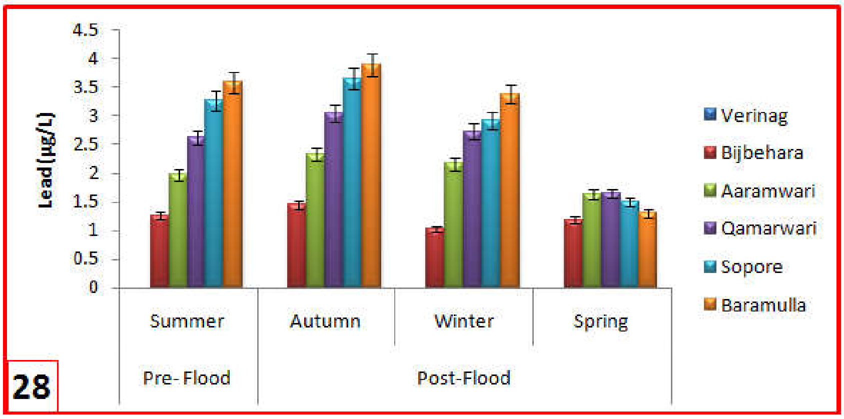

Copper (µg/L)
0
10
20
30
40
50
60
70
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla
23


Iron (µg/L)
0
10
20
30
40
50
60
70
80
90
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla
24


Nickel (mg/L)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla
25


Chromium (µg/L)
0
1
2
3
4
5
6
7
Summer
Autumn
Winter
Spring
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla
26


Cadmium (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
Summer
Autumn
Winter
Spring
Pre- Flood
Post-Flood
Verinag
Bijbehara
Aaramwari
Qamarwari
Sopore
Baramulla
27



Slight acidic pH in post flood season might be due to inputs in the form of organic acids, chemicals, fertilizers from punctual and non punctual sources (Rodriguez and Arauj, 2012). Higher dissolved oxygen can be attributed to low biological activity and water turbulence as supported by earlier workers (Vass *et al.,* 1977; Qadri *et al.,* 1981). Calcium and Magnesium concentrations showed trends similar to that of total hardness, their concentration increase downstream. Significant concentrations of calcium and magnesium might be due to their uptake by the plants in the formation of chlorophyll-prophyrin metal complexes and in enzymatic transformation (Wetzel, 1975). The increased values of chloride in post flood season depicted the anthropogenic influence on the river. The ionic composition of water varied in close relationship with the spatial characteristics in catchment area of river Jhelum. The increased electrical conductivity in the middle stream showed a close relationship with the anthropogenic pressure in urban stretch of the river (Reid, 1961). Decrease in temperature of water in post flood season may be due to meteorological change, decline in air temperature and erratic rainfall at higher altitudes of the state of Jammu and Kashmir (Azizullah *et al.,* 2011; Baqir *et al.,* 2012). In general, most of the physico-chemical parameters increased significantly in post flood season which can be clearly attributed to the phenomenon that flood water entered in open sources and flushed away everything from agricultural fields, settlements, commercial areas, domestic and industrial areas located around river Jhelum (Arnone *et al.,* 2007; Biggs *et al.,* 2011; Badruzzaman *et al.,* 2012; Baqir *et al.,* 2012).

Heavy Metals

Heavy metals are introduced in aquatic ecosystems as a result of the weathering of rocks, volcanic eruptions, and through several human activities involving mining, processing and use of substances that contain metal pollutants. The most common heavy metal pollutants include cadmium, chromium, copper, nickel, lead and iron. Two fundamental sources of heavy metal pollutants are point sources and non point sources. The most common metal pollution in freshwater comes from small and large scale industries effluents (Kashem and Singh, 2001). Lotic water bodies show the presence of several heavy metals such as Pb, Cd, Cu, Fe, Zn etc which dangerously affect the public health and biological systems of the aquatic ecosystems. The presence of elements such as Pb, Cd and Cr in freshwater systems is particularly deemed to be undesirable. The Cd alters normal functioning of arterial systems of the human kidneys; and is highly toxic to fish biology. The Pb is a serious cumulative body poison which is neuro-toxic and can cause gastrointestinal problems (Sharma, 2009; De, 2010). Although elements, such as Fe, Cu and Zn are essential for living organisms but their exposure for sufficiently longer time and in elevated concentrations can also lead to hazardous effects in biological system. The Fe and Cu can directly generate reactive oxygen species leading to oxidative stress of the cellular machinery via Fenton chemistry/Haber-Weiss reaction. Excess Zn can lead to oxidative stress through enhanced production of reactive oxygen radicals leading to cell death due to necrosis (Valco *et al*., 2005; Tiwari *et al.,* 2008). Excess Ni in brain can also induce oxidative damage leading to neurotoxicity in living organisms (Santamaria, 2008; Benedetto *et al.,* 2008; Bhuvaneswari *et al.,* 2014). Zinc concentration of water samples showed significant fluctuation in pre and post flood seasons (Fig. 22). The maximum value reported in pre flood season was 78.5µg/l and in post flood season, its maximum value recorded was 87.3 µg/l. The maximum concentration of copper in pre flood season recorded was 46.46 µg/l and in post flood season, it increased to 61.83 µg/l (Fig. 23). Maximum concentration of Iron recorded in pre flood season was 51.8 µg/l and in post flood season its maximum concentration recorded was 79.3 µg/l (Fig. 24). Ni concentrations varied from 1.17 µg/l in pre flood season to 1.69 µg/l in post flood season (Fig. 25). Highest concentration of chromium recorded in pre flood season was 4.69 µg/l and its maximum concentration recorded in post flood season was 5.74 µg/l (Fig. 26). Cadmium concentration value recorded in pre flood season was 1.98 µg/l and in post flood season, its maximum concentration reached to 2.82 µg/l (Fig. 27). Lead concentration recorded in pre flood season was 3.58 µg/l and in post flood season, the highest value recorded was 3.88 µg/l (Fig. 28).

Out of total water resource in India, 89% is utilised by agricultural sector while domestic and industrial sectors together utilise 11%. However, domestic, commercial and industrial sectors are overwhelmingly responsible for heavy metal pollution in India. Anthropogenic activities have become dominant on the natural causes for increase of heavy metal pollutants in the aquatic environment, which in short can be described as: unscientific mining process; discharge of industrial effluents; unchecked littering, dumping of solid waste garbage, storm water run-off; discharge of untreated or partially treated urban, domestic and municipal sewage into rivers; rural domestic wastewater; application of metal-based biocides and fertilizers in agricultural fields (Times of India, 2014a); discharge of animal waste products; washing of vehicles, dhobi ghats (Times of India, 2014b); industrial emissions and the settling of emitted particles. River ecosystem usually contain very least concentration of heavy metals due to its lotic nature but during catastrophic events, such as floods, Tsunamis, cloud bursts, the overall volume of water inside the river increases but simultaneously the sources of pollution also increase as non punctual sources also add pollution to the river at that time (Mehmood, *et al.,* 2016). Heavy metals showed high seasonal, spatial and temporal variability in the study area. All heavy metals in post flood season were found to get increased due to mainly non punctual sources. The main reason might be due to decrease in binding capacity these heavy metals with fresh sediments of the river (Ravikumar *et al.,* 2013). Finally this study provides a vision that there is the profound impact of floods on the availability and concentration of physico-chemical and heavy metal characteristics of lotic water systems. Nevertheless water concentrations are very changeable, mainly in river ecosystem and some occasional event may cause increase of heavy metal concentration and ultimately results in acute risk for aquatic biota (Pollert and Handova, 2001).

Conclusion

Flood situation caused drastic changes in hydrochemistry of river Jhelum. Concentration of most of the physico-chemical attributes and heavy metals increased in post flood season and decrease in pH has-been recorded. Heavy metals could remobilize from solid material of sediment during extreme flow rates and get released in liquid phase and lead to increase in their concentration in water. Decline in the concentration of few physico-chemical parameters can be attributed mixing of contaminated effluents with large quantity of flood washed water which leads to dilution of pollutants in water body from upstream to downstream of the river. Statistically significant variation was recorded in water quality of river Jhelum in pre and post flood seasons which provides a baseline database for the changes which occur during catastrophic events in aquatic ecosystems. These catastrophic flood events usually lead to short term negative impacts like; destruction of habitat, decimation of aquatic biotic community and probably high acute toxicological risk. But in long term perspective, the flood had also positive effects like wash out of pollutants such as, heavy metals, organic material, nutrients, improving water quality index and more sensitive species appear after the flood. The only long term negative effect of the flood is mostly socioeconomical, but not ecological in nature.

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