World Applied Sciences Journal 9 (6): 674-680, 2010
ISSN 1818-4952

Assessment of Seasonal Variations in Surface Water Quality of Chitral River, North West Frontier Province (NWFP), Pakistan

[1]*Shams Ali Baig,* [1]*Qaisar Mahmood,* [1]*Bahadar Nawab,* [2]*Altaf Hussain and* [2]*Muhammad Nafees*

[1]Sustainable Water Sanitation Health and Development Program, Department of Environmental Sciences, COMSATS Institute of Information Technology, Abbottabad, NWFP, Pakistan
[2]Department of Environmental Sciences, University of Peshawar, NWFP, Pakistan

Abstract: The aquatic ecosystem and catchment's areas of Chitral River are quite rich in biodiversity. However, Chitral River's water quality is being deteriorating day by day due to mismanagement of municipal solid and liquid wastes. Assessment of seasonal variations in surface water quality is an important aspect for evaluating temporal changes of river water quality due to different point and non point pollution sources. In this study an attempt has been made to study different aspects of Chitral River. For this purpose six monitoring stations along Chitral River were selected to collect three times water samples during November, 2003 to August, 2004 on the basis of their catchments as well as tributary joining characteristics. Eleven Physico-Chemical parameters were analyzed on the spot as well as in well equipped laboratory. All the parameters were found within the permissible limits of WHO water quality standards except Total Solids (TS). TS were observed as dominant characteristics through out Chitral River system, where Mulkhow and Arkari Gol streams at sampling stations 2 and 5 respectfully were found most turbid. Proper monitoring and resources accounting systems were recommended to initiate for Chitral River and its tributaries to check the seasonal variations in the surface water quality and quantity.

Key words: Anthropogenic · Biodiversity · Mismanagement · Pollution · Physico-chemical · Variation

INTRODUCTION

Water in general is derived from different sources, depends on the availability of ground water (aquifers) and surface water (rivers, ponds, lakes and reservoirs) [1-4]. Surface waters quality monitoring has been very sensitive issue for huge anthropogenic as well as natural influences results a vast degradation of the surface waters and make worse their use for agricultural, drinking, industrial, recreation and other purposes [5-7]. Water sampling networks for monitoring of rivers' water quality constitute a great source of data for acquiring a spatial and temporal image of the river state [8, 9]. The design of monitoring stations is the transformation of the assessment objectives to specify sampling stations, sampling frequency and the variables to be analyzed. Both sampling frequency and sampling stations are influenced by the water quality and quantity variables being assessed [10, 11].

The world population is increasing at rapid rate during 'Green Revolution' and 'grow more food', man has synthetic kinds of agro chemicals and fertilizers to enhance the agricultural production and leading to enhance the requirement of basic needs for food and products to meet the needs of increasing population. [12]. Pakistan is basically an agricultural country and passing from developing stages. In Pakistan water quality is deteriorating from various activities, like wastewater discharge from industries, agricultural runoff containing fertilizers and pesticides residues. In most urban areas wastewater is disposed in an open drain, in a shallow pit to be emitted later in to a septic tank connected to an open drain, or in to municipal sewers. Wastewater than find their way in to ground water, on which lives of the most of peoples are dependent. Three industrial Estates have been setup in Peshawar, which discharge their untreated wastewater in to Kabul River, which has an average daily discharge of 304 cusecs [13, 14].

Corresponding Author: Shams Ali Baig, Sustainable Water Sanitation Health and Development Program, Department of Environmental Sciences, COMSATS Institute of Information Technology, Abbottabad, NWFP, Pakistan
E mail: shamsalibaig@yahoo.com, Tel: +92.345.9110392

Sanitation and solid waste disposal in the whole of Chitral is deplorable. In the rural areas most people use the countryside for defecation or a corner of their homes from where the excreta is carried by chickens, crows, dogs and donkeys. The situation in the towns is even worse because there are no vacant spaces around houses answering the call of nature. Approximately 10 tones of wastes are being generated in Chitral town every day and burned it in the open atmosphere along the river bank. Individual households burn, bury or throw their rubbish in the river. About 15-25% of houses in Chitral town discharge their latrine effluents into the drains, which convey them to the river. The genesis of the interact able problem of sanitation and solid waste disposal of Chitral is in its topography and the haphazard manner in which its habitations have spring up, because of its mountainous physiography, its population is widely scattered and compressed in to narrow valleys [15, 25]. According to WAPDA (1997) about 1/3rd of the annual runoff and nearly 66% sediments load of the Kabul River is contributed by the Chitral River alone, from just 13% of the catchment's areas [14]. At present in Chitral there are no such large scale industries to pollute the Chitral River. Major sources of pollutants includes solid waste disposal, hotels sewage, vehicles service stations, some domestics sewage, agriculture run off and some hot springs constituents are the most significant from environmental point of view [15].

This study aims was to evaluate the seasonal variations in the surface water quality of Chitral River by analyzing some of the water quality parameters based on different tributaries joining characteristics to the main river system.

MATERIALS AND METHODS

Study Area: Chitral is the northernmost district of Pakistan situated in the Hindukush Mountains, having common boundaries with Afghanistan on the north and west, with the northern areas of Pakistan on the east and Dir and Swat towards the south. It is surrounded by 15000 to 25000 feet high ranges of the Hindukush and Karakuram and is one of the loftiest tracts of land in the country. The main sources of water in Chitral River are glaciers, springs, rainfall and snow melting. Chitral district receives between 250mm to 1000mm rainfall. Chitral River rise in the Chaintar glacier, this river from its source as far as it enters Afghanistan collects numerous hill torrents and streams on both banks. The main valley from its sources to the boarder of Afghanistan is about 220 miles (354 kms) long. The average width is not more than half of a mile and however, it opens to about three miles e.g. at Boroghil, Booni, Chitral Town and Drosh. While at other places it narrows to a defile of less than 200 yards, e.g. Darband, Kuragh, Karbitari and many other places and the side valleys are even narrower [16, 23, 24].

Monitoring Stations: Six monitoring stations were selected based on wide range characteristics of catchments, streams and tributary systems along Chitral River. The main tributary system of Chitral River includes; Mastuj River, Laspur River, Mulkhow River, Reshun Gol, Oveir Gol, Koghuzi Gol, Lotkhow River, Chitral Gol, Ayun Gol, Shishi Gol etc. For this study six monitoring stations along Chitral River are briefly described in Table 1.

Water Sampling and Analysis: Along Chitral River, six locations were selected to collect three times water samples on the basis of their tributary systems and the Parameters like temperature, pH, turbidity, Dissolved Oxygen (DO) and conductivity were recorded in the field with Horiba water quality meter Minami- Ku Kyoto, Japan. Laboratorial evaluations were carried out to analyze 6 chemical water quality parameters i.e. Total Solids (TS), alkalinity, hardness, chloride, sulphate and nitrate. TS, alkalinity, hardness, chloride, sulphate and nitrate were measured according to APHA standard procedures [18]. The same exercises were repeated for three times water sampling from November, 2003 to August, 2004, in order to evaluate the seasonal variations in Chitral River's water quality after joining different tributaries.

Table 1: Six monitoring stations and its locations along Chitral River

Monitoring Stations Number (S#)	Locations	Main Tributary
1	1 km downstream of Mastuj Town	Mastuj River (Upper Chitral)
2	Kuragh Station	Mastuj River (Upper Chitral)
3	Koghuzi Station	Mastuj River (Lower Chitral)
4	Shoghor Station	Lotkhow River (Lower Chitral)
5	1 km downstream of Chitral Town	Chitral River (Lower Chitral)
6	1 km downstream of Drosh Town	Chitral River (lower Chitral)

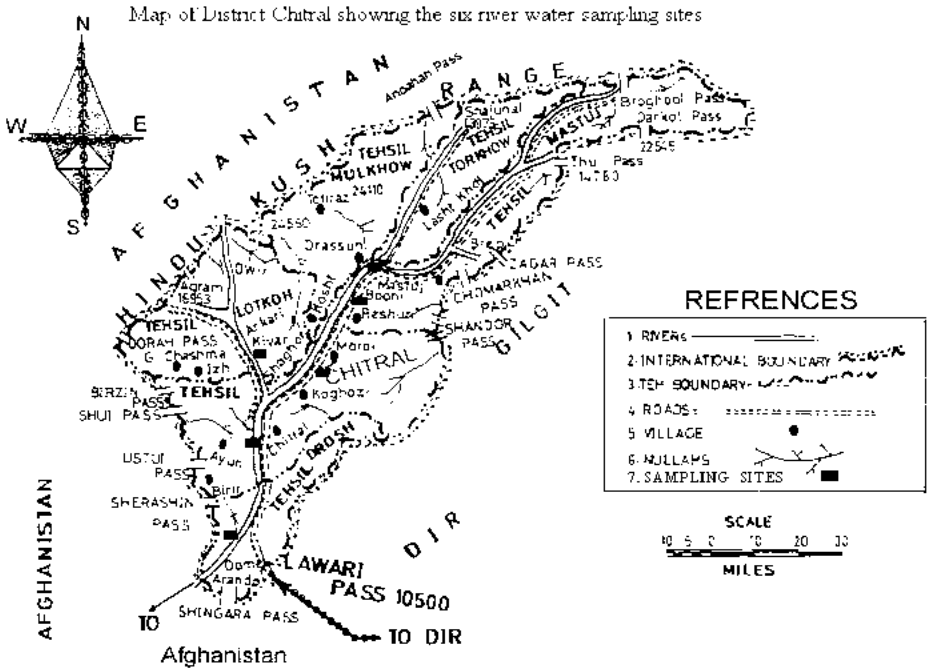

Fig. 1: Chitral map showing water quality monitoring stations along Chitral River [17]

RESULTS AND DISCUSSION

Results: Table 2 showed the investigated results of physical parameters during the three times water quality assessment in six selected monitoring stations along Chitral River. Temperatures during the assessment periods were ranged 2 to 16°C and pH was also within the permissible standards. The most dominant aspect in all the sampling stations was the Total Solids (TS) and enormous TS of 700 mg/L were recoded at Kuragh station (S# 2) in the month of august. That indicated the presence of unstable geologic formations in the catchment's areas of Mulkhow River. At Drosh sampling station (S#6) 580 mg/L TS were recorded, that after few kilometers of flow it enters in to Afghanistan.

Table 2: Results of Physical Parameters in different monitoring stations along Chitral River (Three times water quality assessment)

Monitoring Stations	Month of Sampling	Temp (C°)	pH	DO (mg/L)	Turbidity (NTU)	Conduct--ivity (us/cm)	TS (mg/L)
Mastuj	Nov, 03	2	7.8	13.00	47	310	200
Station (S#1)	April, 04	7	7.8	12.13	51	312	200
	Aug, 04	10	7.6	11.28	58	294	180
Kuragh Station (S#2)	Nov, 03	4	7.4	13.14	104	320	400
	April, 04	11	7.6	11.02	100	330	400
	Aug, 04	10	7.2	11.28	239	310	700
Koghuzi Station (S#3)	Nov, 03	6	7.4	12.44	36	340	200
	April, 04	11	7.5	11.02	38	317	162
	Aug, 04	12	7.4	10.77	31	309	400
Shoghor Station (S#4)	Nov, 03	3	7.3	13.46	78	230	200
	April, 04	12	7.7	10.77	22	273	137
	Aug, 04	13	7.8	10.53	116	193	280
Chitral Station (S#5)	Nov, 03	6	7.2	12.44	47	330	200
	April, 04	11	7.3	11.02	50	320	200
	Aug, 04	14	7.4	10.30	125	290	560
Drosh Station (S#6)	Nov, 03	6	7.4	12.44	108	320	400
	April, 04	16	7.5	9.87	50	313	200
	Aug, 04	16	7.4	9.87	125	290	580

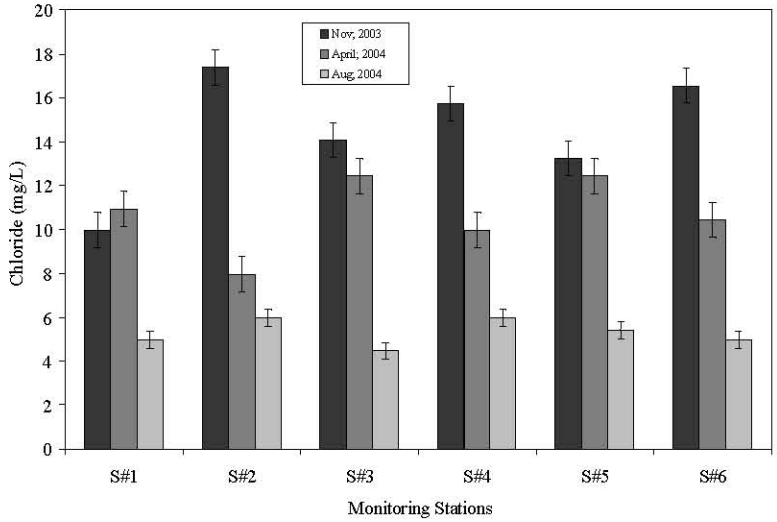

Fig. 2: Chloride

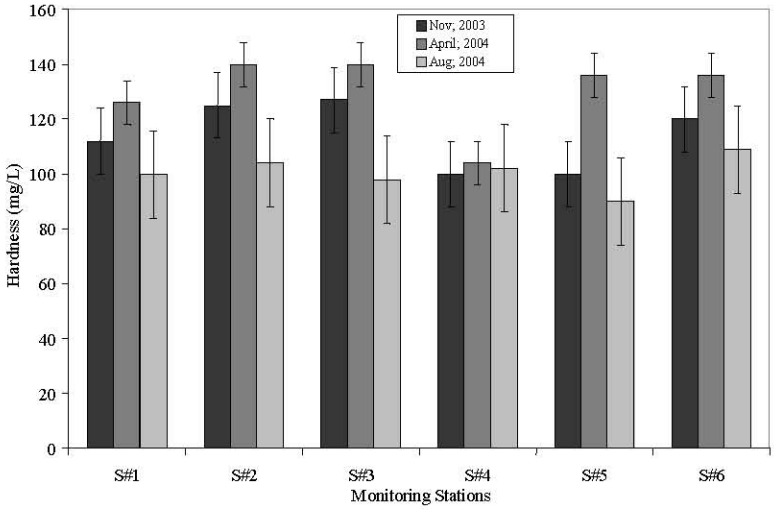

Fig. 3: Hardness

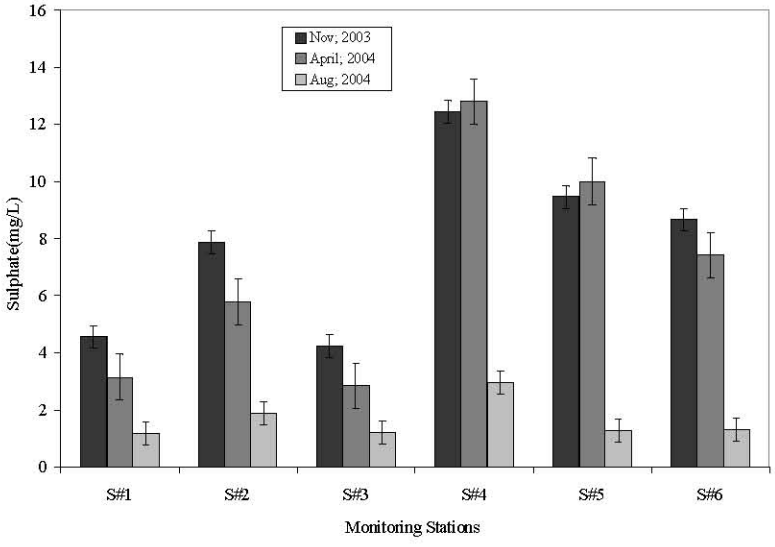

Fig. 4: Sulphate

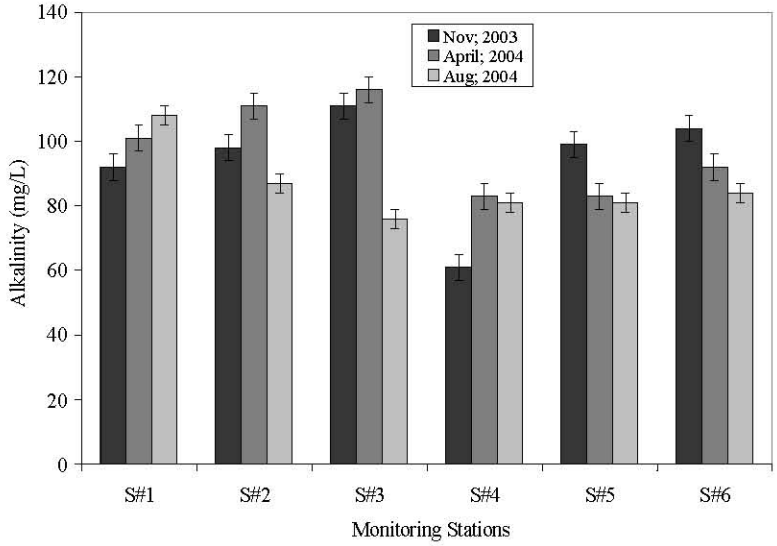

Fig. 5: Akalinity

Fig. 2-5: Seasonal variations in the surface water chemical quality parameters i.e. chloride, hardness, sulphate and alkalinity during the three times assessment (Nov; 2003, April and Aug; 2004) in the six monitoring stations along Chitral River.

Chemical parameters i.e. chloride, hardness, sulphate and alkalinity were analyzed according to the APHA standards procedures. Nitrate was also assessed, but it was not under the detectable limits during the assessment period. Figures 2 to 5 showed significant variations in different parameters during the assessment periods in various monitoring stations. Chloride, hardness, sulphate and alkalinity were observed high in November, 2003 and April, 2004 assessment time periods, where sulphate was found comparatively high during the three times monitoring period at Shoghor station (S# 4). All the analyzed parameters showed high values in November, 2003 and April, 2004 assessment time periods. All the chemical parameters in august, 2004 showed comparatively low values due to dilution at the high flow rate of 7.0 MAF in august.

DISCUSSION

Experimental results indicated enormous seasonal variations in Total Solids (TS) during the three times water samplings from November, 2003 to August, 2004. TS ranged from 50 to 700 mg/L in various tributary systems, where Mulkhow River at Kuragh station (S# 2), Arkari Gol at Chitral station (S# 5) and Chitral River at Drosh station (S# 6) were observed 700 mg/L, 560 mg/L and 580 mg/L respectively in the month of August (Table. 2). The high concentrations were as a result of high rate of snow melting in the mountains, deforestation and geological process contributed the sediments in the tributaries. However, IUCN (1994) conducted a comprehensive study of Kabul River's tributary system, where Chitral River was found safe for drinking except suspended solids, which were associated with soil erosion, steep topography and deforestation along the riverbanks and catchment's watershed areas [15]. Later on Amjad (1996) quantitatively and qualitatively analyzed Kabul River's tributary systems for suspended solids. So, in Kabul River system Chitral and Bara Rivers were found most turbid with 1112 mg/L and 1152 mg/L respectively [19]. Moreover, Rehman *et al.* (2003) considered Chitral River is one of the most significant rivers of NWFP in terms of its annual flow and sediments yield per square kilometers of the drainage basin (1842 km^2/a) that indicated high denudation rate in Chitral River's catchments [14].

Figure 2 showed the chloride variations over assessment time where low chloride concentration in the month of August indicated the dilution of more water as a result of high glacier melting. Hardness was found comparatively high in the month of April, because of the lower River flow resulted high dissolution of carbonate materials in the mountains. Sulphate concentration was comparatively high in Chitral River as compared to the other tributaries of Kabul River, that because of some hot springs are present in the catchment's areas of Chitral River containing Sulphur, where Lotkhow River's water possessed highest concentration of sulphate (12.4 mg/L) as compared to the other tributaries. This was because of

the hot springs water of Garum Chashma (place of hot spring). Nitrate was found below the detectable limits, shown the indication that the agricultural runoff not reached to the River due to its less quantity and high porosity in the soil. Alkalinity variations were comparatively equilibrium during the assessment period, where high alkaline water was observed at monitoring station 3, which results of huge mountains range in the upstream tributary system. Most of previous literatures pointed out the alarming deplorable water quality situation in Chitral and stated that prior the intervention of NGOs in water supply sector in early 1980s, majority of Chitral populations were relying on Chitral River water for their supply [20-22]. As a result of the deplorable quality of River's water high intestinal worms, skin, digestive troubles, eye diseases, goiter, malaria, cholera and small pox diseases were common in Chitral in general and other part of Pakistan in particular [26,27].

CONCLUSION

Chitral River is among one of the most important fertile tributary discharging 7.0 MAF annually to Kabul River. The Chitral River is a vital natural resource of Pakistan and plays an important role in agricultural and hydrel power productivity of the region from stream runoff. Besides, it contribute to the richness of the plain areas of Pakistan have been built by alluvial soil brought by rivers including Chitral River. It provides food to aquatic organisms in down areas of the country. Based upon the experimental investigations all the physical and chemical parameters are within the permissible limits of National and International standards except Total Solids, because of the high land degradation and steepness of topographic features caused high sediments load in Chitral River. Proper monitoring and resources accounting systems were recommended to initiate for Chitral River and its tributaries to check the seasonal variations in the surface water quality and quantity.

ACKNOWLEDGEMENT

The authors express their gratitude to the management of Aga Khan Rural Support Program (AKRSP) Chitral, Water and Sanitation Extension Program (WASEP) Chitral and International Union of Conservation of Nature (IUCN) Chitral for sponsoring the field activities.

REFERENCES

1. Baig, J.A., T.G. Kazi, M.B. Arain, H.I. Afridi, G.A. Kandhro, R.A. Sarfraz, M.K. Jamal and A.Q. Shah, 2009. Evaluation of arsenic and other physico-chemical parameters of surface and ground water of Jamshoro, Pakistan, J. Hazardous Materials, 166: 662-669.
2. Ouyang. Y., 2005. Application of principal component and factor analysis to evaluate surface water quality monitoring networks. Water Res., 34: 713-724.
3. Loukas, A., 2010. Surface water quantity and quality assessment in Pinios River, Thessaly, Greece. Desalination, 250: 266-273.
4. Eisakhani, M. and A. Malakahmad, 2009. Water quality assessment of Bertam River and its Tributaries in Cameron highlands, Malaysia. World Appl. Sci. J., 7(6): 769-776.
5. Simeonov, V., J.A. Stratis, C. Samara, G. Zachariadis, D. Voutsa, A. Anthemidis, M. Sofonious and T. Kouimtzis, 2003. Assessment of the surface water quality in Northern Greece, Water Res., 37: 4119-4124.
6. Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley and V.H. Smith, 1998. Non point pollution of surface waters with phosphorus and nitrogen. Ecol Appl., 8(3): 559-68.
7. Jarvie, H.P., B.A. Whitton and C. Neal, 1998. Nitrogen and phosphorus in east coast British rivers, Science Total Environ., 210-211: 79-109.
8. Dean, R.B., Ternero-Rodrı, M., Ferna´ndez-Espinosa, A.J., 2008. Trend study and assessment of surface water quality in the Ebro River (Spain). J. Hydrol., 361: 227-239.
9. Sharma, R. and A. Capoor, 2010. Seasonal variations in physical, chemical and biological parameters of Lake water of Patna Bird Sanctuary in Relation to Fish Productivity. World Appl. Sci. J., 8(1): 129-132.
10. Strobl, R.O. and P.D. Robillard, 2008. Network design for water quality monitoring of surface freshwaters: a review. J. Envir. Management, 87: 639-648.
11. Khalil, B., T.B.M.J. Ouarda, A. St-Hilaire and F. Chebana, 2010. A statistical approach for the rationalization of water quality indicators in surface water quality monitoring networks. J. Hydrol., 386: 173-185.
12. Trivedi, R.P. and G. Raj, 1992. Water Pollution 1st Edition, Akshdeep Publishing House, New Dehli, India.

13. GOP/EUAD, 1987. Environmental Profile of Pakistan, Islamabad, pp: 72-85.
14. Rehman, S.S. and A.M. Sabir, 2003. On the Water and Sediment Field of Chitral River Pakistan, J. Science and Technology, University of Peshawar, pp: 53-61.
15. International Union of Conservation of Nature (IUCN) and Environmental Planning and Management (EPM) 1994. Pollution and the Kabul River, published by Khyber press Peshawar.
16. Israr, D., 1965. A Social Geography of Chitral State, M. Sc Thesis, University of London.
17. Geography of Chitral, www.chitraltimes.com/gerography/map.pdf (accessed on 25th March, 2010).
18. Franson, A.M., 1985. Standards Methods for the Examination of Water and Wastewater, 16th Edition, American Public Health Association 1015 15th Street Washington, DC 20005.
19. Amjad, M., 1996. Quantitative and Qualitative Analysis of the Suspended Sediment for Rivers of NWFP, M Phil thesis, National Center of Excellence in Geology, University of Peshawar, pp: 35-56.
20. Millitary Report and Gazetter on Chitral, 1928. Edited by General Army Staff of India, Calcutta Government of India Press.
21. Robertson, S.G., 1987. The Kafirs of the Hindukush, Sange Publication, Lahore.
22. Manahan, S.E., 1994. Environmental Chemistry, Sixtth Edition, McGraw Hill Company, UK.
23. Nafees, M., 2000-2002. Environmental Study of Kabul River and its Tributaries in North West Frontier Province (NWFP) Pakistan, M. Phil Thesis, Deptt of Environmental Sciences, University of Peshawar.
24. Rehmatullah., 1995. The Socio Geographical Study of Mastuj Village in District Chitral, M.Sc Thesis, Deptt of Geography, University of Peshawar).
25. Chitral Conservation Strategy, 1997. International Union of Conservation of Nature, IUCN Pakistan. www.iucnp.org/ccs.pdf (accessed on 25th March, 2010).
26. WHO, 1996. Guideline for Drinking Water Quality, Volume 2, Health criteria and other supporting information, 2nd edition, Geneva, Switzerland.
27. Iqbal, M., M. Qasim, A. Khan, R. Rashid, S. Nasreen, Q. Mahmood and J. Khan, 2009. Surface water quality risk assessment through UV-Visible Spectrophotometer. World Appl. Sci. J., 7(9): 1195-1202: 2009.