Monitoring of Water Pollution in the Kabul River (Pakistan) Under Low Flow Conditions

SHAH ALAM KHAN AND MUMTAZ KHAN
PCSIR Laboratories, P.O. Peshawar University, Peshawar-25120, Pakistan

(Received 20th October, 1996, revised 14th March, 1997)

Summary: The quality of the Kabul river water from upstream of Warsak Dam to its confluence with the Indus has been investigated by measuring 15 physical and chemical parameters during low flow conditions between September 1992 and March 1993. These values have been compared with standard conditions required for the maintenance of fisheries and aquatic life. The Kabul river water showed high suspended solids which range between 10 - 800 mg L^{-1}. Conductivity values were also high and a maximum value of 1415 was recorded below the Akbar tannery on the Naguman branch. High levels of ammonia, nitrites and nitrates existed in the Shah Alam branch and in the lower main river. Sulfide concentration were high over the whole stretch of the river.

Introduction

The Kabul river originates from the base of the Unai pass in the Paghman mountains in Afghanistan [1]. It then passes through Kabul approximately 72 km from its source before entering Pakistan at Shalman in the Khyber Agency. Below the Warsak Dam it divides into three main distributary channels namely Adezai, Naguman and Shah Alam before joining the river Indus at Kund (Fig. 1).

The monthly discharge of the Kabul river when measured at Warsak Dam shows high seasonal variability. The average discharge is 9537 cusecs during the low flow period from September to April. The whole area is very arid and any rainfall influence is largely masked by glacial inputs.

The Kabul river watershed is geologically complex. Most of the lower basin is underlain by the sedimentary limestone and shales that are common in the Indus basin, while the headwaters of the main tributaries rise among very complicated sets of igneous and metamorphic rocks.

Fifty-four fish species have been identified from the Kabul river of which about thirty-five are described as common. Many of these fish belong to the carp and mystus families. One species, Botia rostrata, has only been reported from Pakistan in the Kabul river at Michni [2,3].

A survey of hazardous waste producing industrial units in NWFP lists 348 industries of which there are many within the Kabul river watershed; 4 sugar mills, 2 distilleries, 3 ghee (edible oil) factories, 5 textile mills, 2 woolen mills, 12 tanneries, 3 paper and board mills, 10 chemical and pharmaceutical factories, 4 match factories, 10 soap industries, 1 petroleum refinery, 1 photo laboratory, 4 paint and varnish industries and 11 rubber and plastic industries. Virtually no water treatment facilities exist.

The aim of the present study was to investigate the pollution load in the river by measuring a total of 15 physical and chemical parameters and to compare the values with standard conditions required for the maintenance of fisheries and aquatic life, as fish population had substantially declined within the river. This was undertaken during low flow conditions, when organic pollution was anticipated to be at its worst.

Results and Discussion

The results are shown in Table-1, which presents a comprehensive picture of the water of the Kabul river and its tributaries with respect to the 15 physical and chemical indicators chosen. The table gives the values of the measured parameters, arithmetic mean and standard deviation. The results of the chemical analyses were

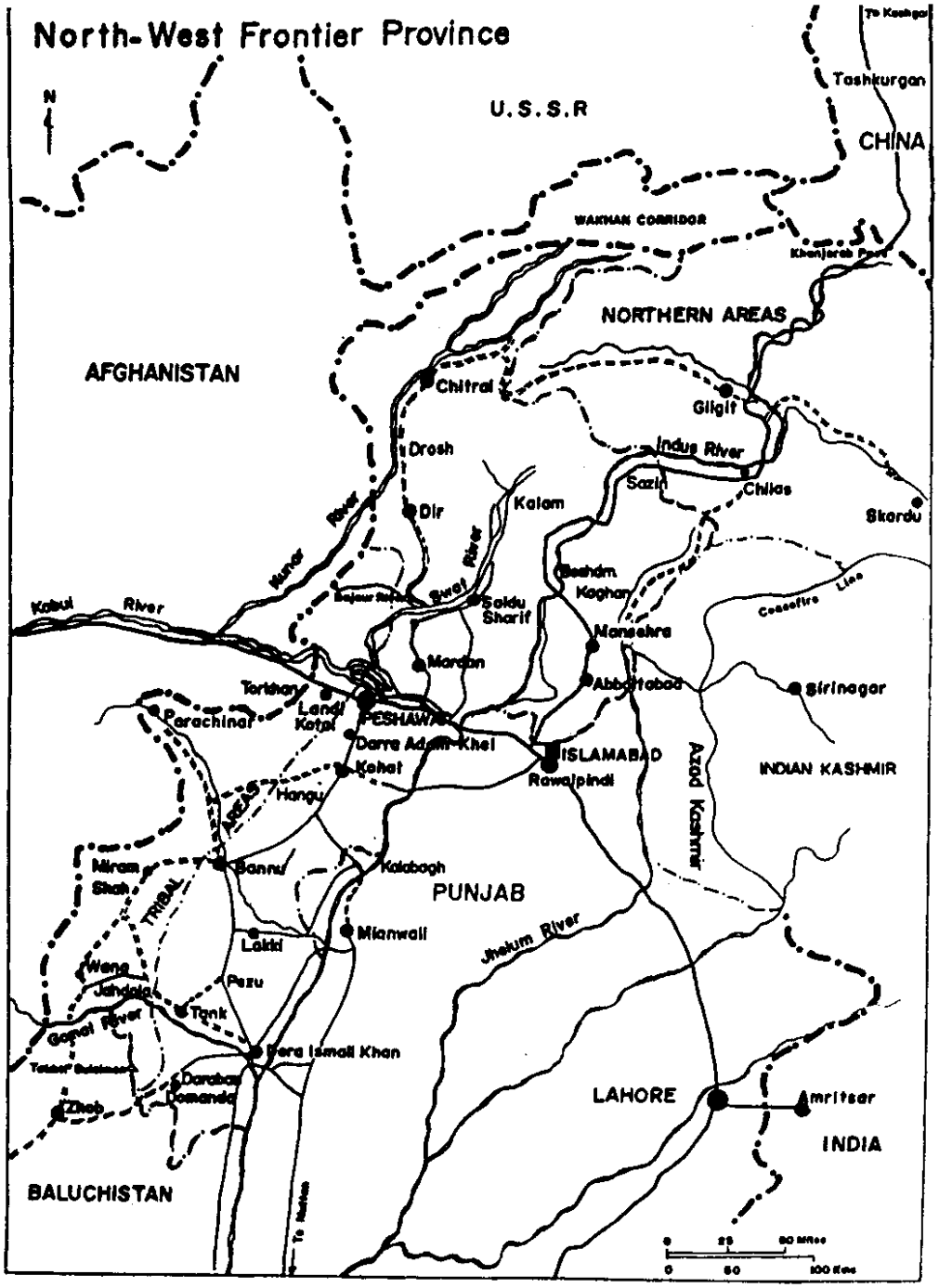

Fig. 1: The Kabul River and its Tributaries

compared with generally accepted water quality standards from other countries for the maintenance of fisheries and aquatic life. Those variables which fell outside the acceptable limits, and those considered fundamental to water quality assessment are displayed graphically (Figs 3 and 4).

From the Table-1 it can be seen that the dissolved oxygen (DO) levels in the river water are generally good and above the recommended levels of 5 mg L^{-1} necessary for fisheries and aquatic life. The only stretch where DO levels fall is in the Shah Alam branch where the Khazana Sugar Mi

Table-1: Physical and chemical characteristics of water of the main river and its tributaries (mg L^{-1}, except where indicated)

	NO_2^-	NO_3^-	NH_3-N	PO_4^{3-}	Cl^-	SO_4^{2-}	S^{2-}	Alkalinity as $CaCo_3$	Hardness as $CaCO_3$	DO	BOD	COD	pH	Temp. (°C)	Conductivity (μ S cm^{-1})
1	0.000	2.81	0.000	0.14	7	26	0.16	75	167	6.5	0.8	23	7.4	20	263
2	0.000	3.34	0.000	0.14	6	24	0.16	75	167	9.0	0.5	23	7.7	20	263
A3	0.000	1.24	0.000	0.40	4	25	0.18	82	113	6.3	1.0	23	7.7	20	285
A4	0.025	20.00	0.000	0.29	6	29	0.40	75	175	6.0	1.1	69	7.7	24	280
A5	0.015	2.24	0.007	0.23	12	19	0.32	99	153	5.8	1.6	58	8.3	25	305
A6	0.080	2.47	0.019	0.15	10	20	0.45	148	136	5.7	1.9	37	7.9	27	274
N3	0.000	0.02	0.003	0.00	11	42	0.24	94	214	5.9	2.3	7	7.4	20	360
N4	0.000	10.88	0.001	0.19	5	17	0.38	83	121	5.9	1.3	82	7.2	25	243
N5	0.016	0.95	0.080	3.10	54	89	0.20	186	640	5.7	2.4	60	8..1	21	1415
N6	0.170	1.92	0.008	3.13	8	28	0.20	150	145	6.0	1.9	4	7.7	26	295
S3	0.010	100.00	5.160	0.02	47	279	0.80	228	405	7.5	17.0	743	7.7	11	775
S4	0.000	1.17	0.850	3.10	52	82	1.00	90	118	7.2	6.7	95	6.9	12	1002
S5	0.837	7.23	0.000	0.20	18	55	0.50	182	217	5.8	3.0	43	8.0	13	520
S6	1.137	11.18	0.000	0.63	26	52	0.24	282	318	5.5	5.0	51	7.9	13	731
S7	0.000	0.00	4.200	0.70	32	58	0.80	340	333	5.0	6.1	129	8.1	14	855
8	0.089	5.82	0.000	0.04	13	51	0.32	194	258	6.0	2.8	28	7.6	24	612
9	0.021	3.78	0.031	0.38	4	67	1.00	120	154	6.8	2.0	20	7.3	22	362
10	0.024	1.09	0.400	0.14	10	50	0.24	90	154	6.9	2.7	48	6.8	18	337
11	0.031	1.07	0.123	0.05	10	77	0.64	224	148	7.5	3.1	140	6.8	23	371
12	0.016	1.14	0.506	0.11	11	26	0.10	158	160	7.3	3.1	143	8.3	19	331
13	0.078	1.27	0.401	0.15	9	32	0.32	171	150	6.0	7.7	110	6.3	20	361
14	0.000	1.33	0.403	0.40	18	26	0.40	221	152	6.2	6.8	43	6.4	20	435
15	0.010	2.66	0.702	0.01	9	280	0.40	90	164	7.1	4.1	39	8.1	19	344
16	0.041	1.83	0.710	0.11	13	16	0.60	145	150	7.3	5.3	20	7.4	20	414
17	0.092	0.33	0.960	0.02	16	25	0.60	152	169	7.0	5.0	107	7.7	17	422
18	0.095	1.77	0.518	0.09	17	24	0.80	150	171	7.5	3.9	107	7.5	17	425
19	0.165	15.77	0.000	0.32	11	37	0.39	210	182	6.5	4.7	191	7.7	16	488
20	0.194	2.59	2.140	0.14	16	32	0.80	148	176	6.5	6.7	62	8.1	18	452
21	0.578	7.15	1.700	2.07	20	87	0.80	185	185	6.5	4.4	90	7.5	18	490
22.	0.112	10.81	0.308	0.14	7	46	0.80	133	170	7.0	3.2	82	7.5	15	403
Mean	0.128	7.46	0.641	0.54	16	57	0.47	153	199	6.5	3.9	89	7.5	19	470
SD	0.253	17.85	1.200	0.93	13	63	0.27	64	104	0.8	3.1	129	0.5	4	253

effluents increase the biological oxygen demand (BOD) and chemical oxygen demand (COD) values. Some 5 km further downstream both the BOD and COD values have fallen but rise again with the entry of the Budni Nullah and Ganda Erab, each carrying sewage effluent from Peshawar.

BOD values in the river water are generally acceptable, with the exception of downstream of Khazana Sugar Mill. COD values are those expected of a polluted river, although at no point do they reduce dissolved oxygen concentrations to undesirable levels (Fig. 3).

Nitrites are usually present in very low concentrations in freshwater of < 0.001 mg L^{-1}, and are rarely higher than 1 mg L^{-1} [4]. High nitrite levels are generally indicative of industrial effluents. Nitrite concentrations appear high at two places, the Budni Nullah on the Shah Alam, and the Corn Complex on the lower main river. Both of these sites are just downstream of two of the highest recorded ammonia values and may be due in part to the nitrification of the ammonia rather than industrial effluent discharges (Fig. 4).

Natural levels of nitrate seldom exceed 0.1 mg L^{-1} but when influenced by human activities may contain up to 5 mg L^{-1}. Levels in excess of 5 mg L^{-1} usually indicate pollution by human or animal waste or fertilizer run-off. In case of extreme pollution, concentrations may reach 200 mg L^{-1} [4]. Nitrate levels in the Kabul river show the influence of human activity almost throughout and in one instance downstream of Khazana Sugar Mill, one may see the effect of severe pollution. Maximum values for maintaining fisheries and aquatic life < 40 mg L^{-1}, so only at Khazana they are excessive.

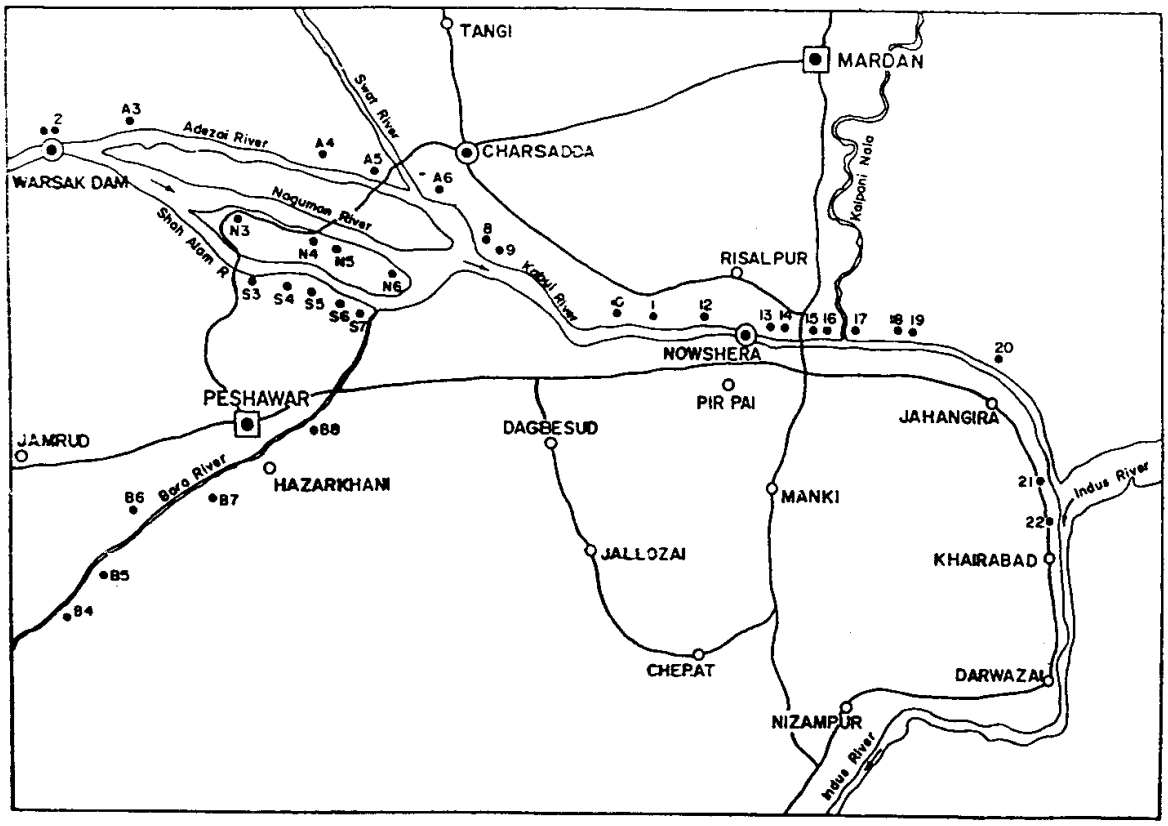

Fig. 2: (a) Location of Sampling Sites

The concentration of sulfides appear to be very high and the values of < 0.05 mg L^{-1} have been shown to cause complete mortality of fish [5]. Concentrations are generally higher under low flow conditions although the Naguman would appear to be an exception. However, the pH of the Kabul river water is between 6.3 and 8.3 and according to [4] sulfide concentrations need not be considered if the pH is less than 10. This is because at low pH sulfide exists as non-ionized molecules of hydrogen sulfide (H_2S) and hydrosulfide (HS^-) with negligible concentrations of sulfide ion (S^-) (Fig. 4).

Experimental

The whole length of the Kabul river from just above Warsak Dam to its confluence with the Indus at Khairabad was walked between September 1992 and March 1993. Samples were collected in polyethylene bottles from 30 points throughout the Kabul rive, Fig. 2(a) and 2(b) show the locations of the sampling stations. Standard methods were used for the determination of the chemical and physical characteristics of the water [6].

The parameters studied are temperature, pH, conductivity, chloride, sulfate, total alkalinity, total hardness, nitrate, nitrite, ammonia, phosphate, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and sulfide, pH was measured using a portable pH meter (Pye Model 78) and conductivity by a conductivity meter (Orion Research Model 1-101). Chloride was determined by titrating against

Sampling point Number	Location of Sampling Point	Disance Downstreem of Warsak Dam
		Km
1	Upstream of Warsak Dam	0
2	Downstream of Warsak Dam	0.5
	ADEZAI BRANCH	
A3	Adezai branch at Michni bridge	7
A4	Adezai branch at Adezai bridge	23
A5	After mixing of Cutyala Canal	27
A6	At Sardaryab, after mixing of Swat River	33
	NAGUMAN BRANCH	
N3	Naguman branch of Dung Lakhtai	16
N4	Naguman at Naguman bridge	24
N5	After mxing with Akbar Tannery	25
N6	Naguman at Jala Bela	30
	SHAH ALAM BRANCH	
S3	Downstream of Khazana Sugar Mill	23
S4	After mixing of Tooti Tannery	25
S5	After mixing of Kankola Canal	28
S6	After mixing of Budni Nullah	30
S7	After mixing of Ganda Erab	33
	MAIN KABUL RIVER	
8	After mixing of Bara River	36
9	Shabara near Jindi	37
10	Dehri Zardad	48
11	After mixing of Zagai Khwar	50
12	Kabul River at Kheshki	54
13	Downstream of Sarhad Colony Textile Mill	58
14	Downstream of Associated Ghee Industries	59
15	After mixing of Nowshera Kalan Sewage drain	61
16	After mixing of Nowshera Cantt. sewage drain	62
17	After mixing of Cantt. board sewage drain	64
18	After mixing of Badrashi sewage drain at Nowshera	65
19	After mixing with Kapani River at Pirsbak	69
20	After mixing of Akora Khattak sewage drain	76
21	After mixing of Corn Complex sewage drain	86
22	Kabul River Khairabad	90

Fig. 2: (b) Key to River Sampling Points

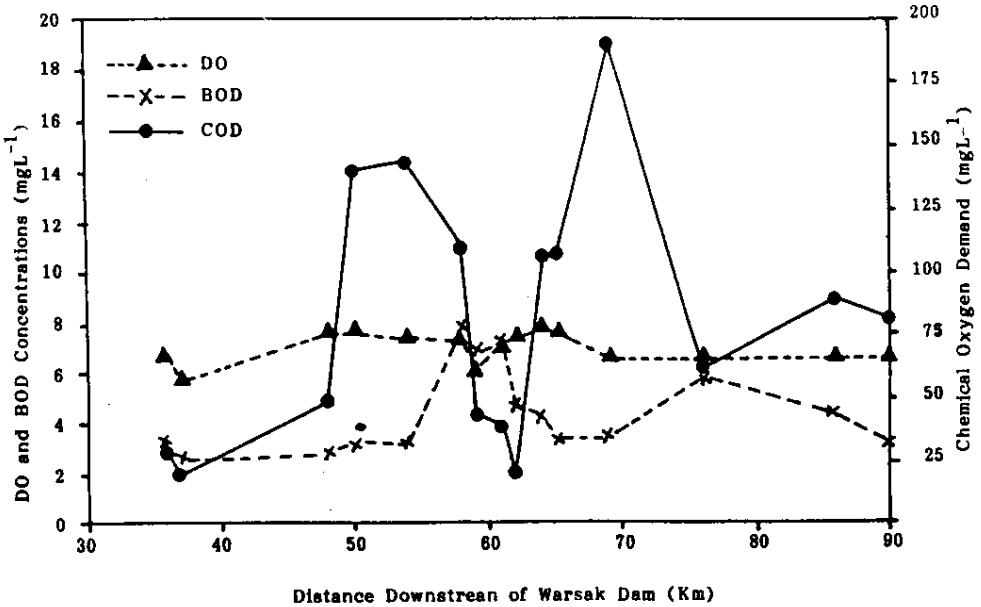

Fig. 3: DO, BOD and COD Levels in the Lower Kabul River.

silver nitrate (0.1 N) using potassium chromate as indicator. Analysis for total alkalinity was carried out by titration against standard sulfuric acid and total hardness and sulfate were analysed by complexometric titrations using EDTA (0.01 M). Spectrophotometric methods were applied for the analysis of phosphate and ammonia using Nessler's reagent.

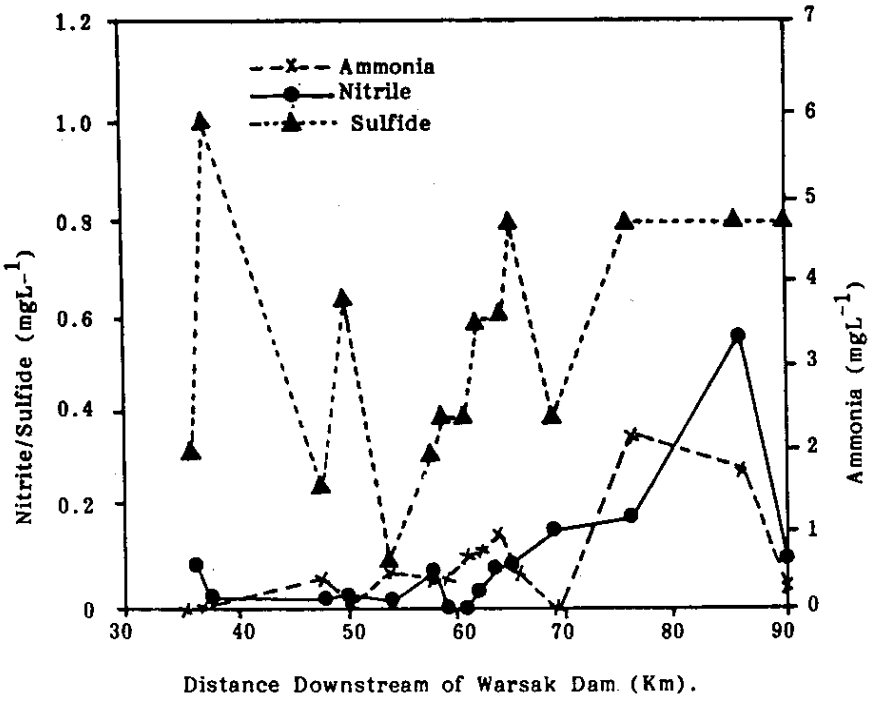

Fig. 4: Ammonia, Nitrite and Sulfide Levels in the Lower Kabul River.

Prior to each analysis, all instruments were calibrated according to the manufacturer's recommendations. All reagents used were of analytical research grade from E. Merck and BDH.

Conclusions

To Kabul river may be considered as relatively polluted river. This is due to the high suspended solids which range between 10-800 mg L^{-1} under low flow conditions. Conductivity values are also high throughout the river and related to the concentrations of total dissolved solids and major ions. Abnormal values are in several cases indicative of pollution, such as below the Akbar Tanney on the Naguman where a value of 1415 was recorded.

Kabul river water is high in magnesium and calcium and is 'hard' water under low flow conditions. The water is also high in alkalinity which is important for buffering pH changes, and for complexing with heavy metals to reduce their toxicity.

Organic pollution is at its worst in the Shah Alam branch where oxygen concentrations decreased steadily downstream, and ammonia is present at value which, if not toxic to fish must be extremely stressful.

Sulfide concentrations were high over the whole stretch of the survey. However, due to the pH value of the water they are not as toxic as might be presumed. The survival of fish species in the river supports this view.

Acknowledgement

The authors wish to thank IUCN - The World Conservation Union Pakistan and the Department of Environmental Planning and Management, University of Peshawar for their support and assistance during the study.

References

1. R.K. Gresswell and A. Huxley, " Standard Encyclopaedia of the World's Rivers and Lakes", Weidenfield and Nicholson (1965).
2. J.A. Butt, "A Liminological Study of Lotic Water of NWFP Pakistan, Final Technical Report", Pakistan Agricultural Research Council (1989).

3. J.A. Butt and M.R. Mirza, NWFP *Biologia,* **27**(2) (1981).
4. D. Chapman, "Water Quality Assessment". Chapman and Hall, London(1992).
5. Anon, "Quality Criteria for Water", US EPA Office of Water and and Hazardous Materials, Washington DC (1976).
6. APHA (American Public Health Association), "Standard Methods for Examination of Water and Wastewater", 16th ed., APHA, Washington DC (1985).