Water Quality Characteristics of the Kabul River in Pakistan under High Flow Conditions

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Summary:The Kabul river water has been investigated with respect to temperature, pH, conductivity, chloride, sulfate, total alkalinity, total hardness, nitrate, nitrite, ammonia, phosphate, DO, BOD, COD, and sulfide during high flow conditions between June-August 1993. These values have been compared against standards for the maintenance of fisheries and aquatic life. Two major water quality issues have emerged from this river water survey. These are; organic water pollution, particularly in the Shah Alam branch and lower main river, and sulfide concentration especially in the naguman and Shah Alam branches and lower main river.

Introduction

The Kabul rivers enters Pakistan at Shalman in the Khyber Agency. It then flows through the Khyber and Mohmand Agencies flanked by Koh-i-Sufaid mountains until reaches Warsak Dam (Fig. 1). Below the dam it is diverted into several canals and divides into three main distributary channels, namely Adezai, Naguman, and Shah Alam.

The average monthly discharge of the river is 38120 cusecs during the flow period from May to July. The significant variation is a result of seasonal glacial and snow melt.

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 that result from the plate tectonics and mountain-building processes that are active around the edges of subcontinent.

Fifty-four fish species have been identified from the river of which about thirty-five are described as common. Many of these fish belong to the carp and mystus families. One species, Botia rostrate, has only been reported from Pakistan in the Kabul river at Michni (Butt, 1989, and Butt and Mirza, 1981). The benthic invertebrates have been described by Butt (1989), and freshwater algae by Fazal-i-Hadi *et al.* (1988).

A survey of hazardous 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. Virtually no water treatment facilities exist.

The Kabul river is mainly used for irrigation, effluent and waste disposal, watering livestock, fishing, recreation, transportation, washing and bathing. For quite a long time the villagers living on the banks of the Kabul river had been complaining about pollution in the river. The complains were the result of the increasing obvious signs of pollution, including periodic fish kills. The river had also been blamed for a high prevalence of skin diseases in humans as well as maladies in livestock. Some people had complained of reduced crop yields in field irrigated with water polluted with industrial effluents.

So the principal objective of the study were to determine the locations where polluted effluents were being discharged into the river and the types of pollution. This was undertaken during high flow conditions while the result under low flow conditions have been presented in our earlier publication (Khan, 1996).

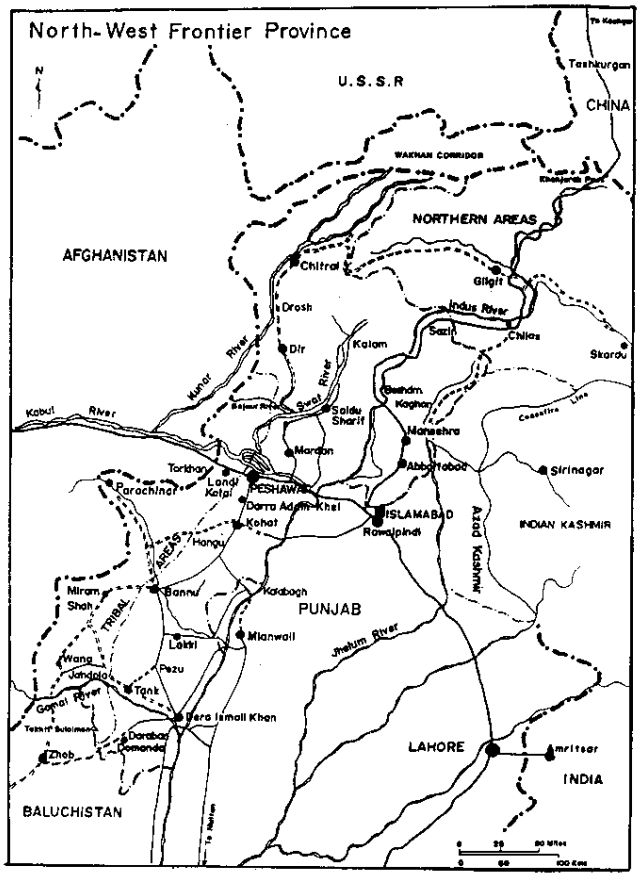

Fig. 1: The Kabul River and its Tributaries.

Results and Discussion

The results are shown in a table, which presents a comprehensive picture of the properties 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 analysis were compared with generally accepted water quality standards from other countries for the maintenance of fisheries and aquatic life. Those variables which fell outside acceptable limits and those considered fundamental to water quality assessment are displayed graphically (Figs. 3 and 4).

From the table it can be depicted that the dissolved oxygen (DO) levels within the river are generally good and above the usually recommended levels of 5 gm/l necessary for fisheries and aquatic life. BOD values within the river are generally acceptable, whereas, COD values are generally higher under low flow conditions, although COD below the corn complex at 560 gm/l during high flows is an exception (Fig. 3).

Ammonia is extremely toxic to fish and should be present at levels which are ideally below 0.2 mg/l. Values above 2 mg/l total ammonia are usually an indication of serious organic pollution (Chapman, 1992). According to this criteria the lower main river is stressful for fish and aquatic life and subject to organic pollution (Fig. 4).

Nitrites are usually present in very low concentrations in freshwater of < 0.001 mg/l, and are rarely higher than 1 mg/l (Chapman, 1992). High nitrite levels are generally indicative of industrial effluents. Nitrite concentrations appear high at only one place, the bundi Nullah on the

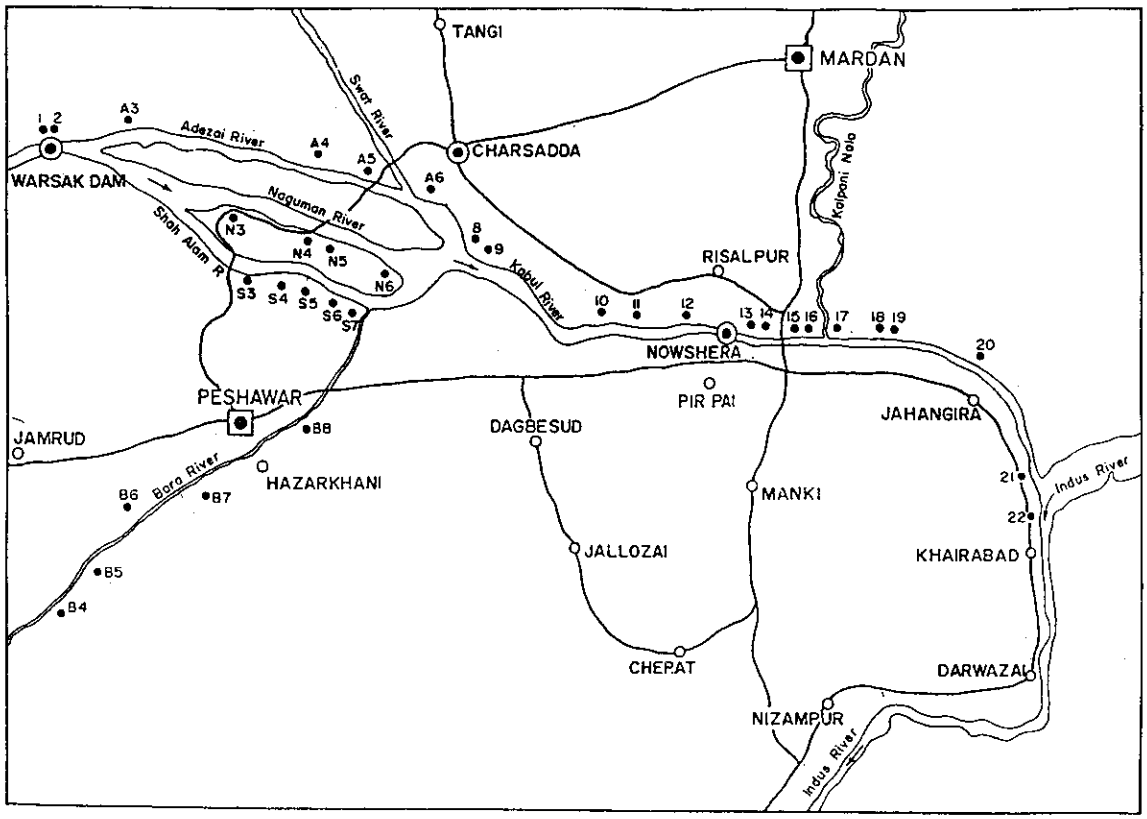

Fig. 2: Location of Sampling Sites

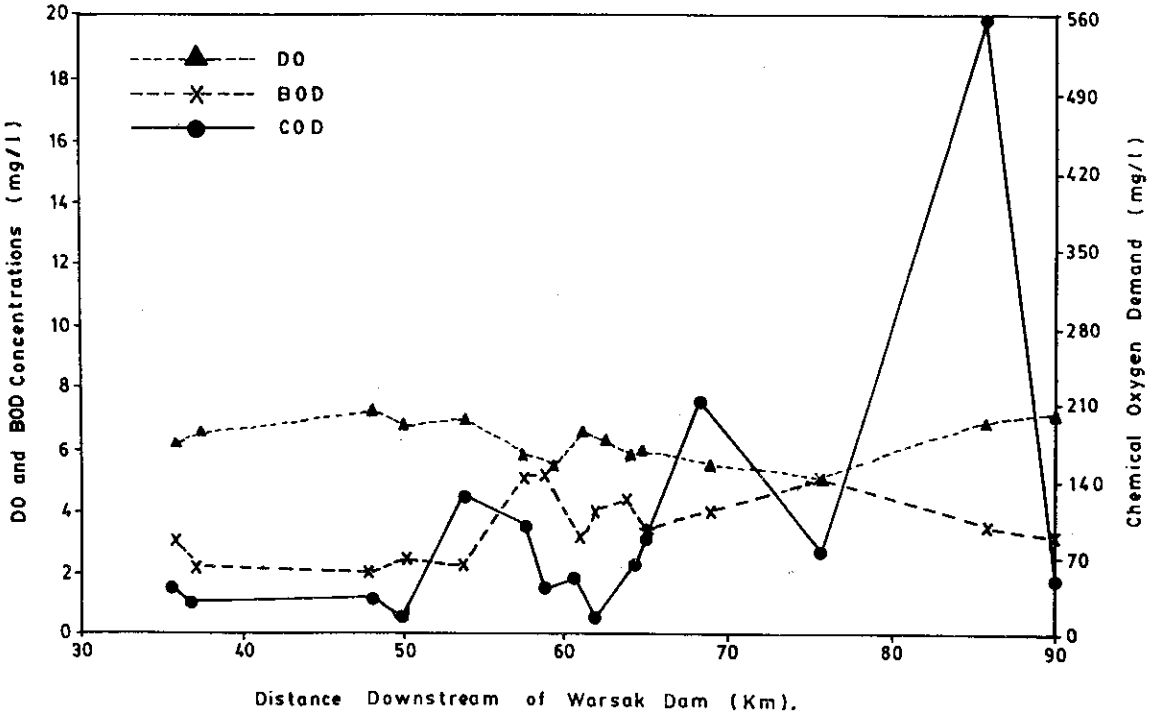

Fig. 3: DO, BOD and COD Levels in the Lower Kabul River.

Sampling point Number	Location Sampling Point	Distance Down-stream of Warsak Dam
		Km
1	Upstream of Warsak Dam	0
2	Dewnstream of Warsak Dam	0.5
	ADEZAI BRANCH	
A3	Adezai branch of Michni bridge	7
A4	Adezai branch of Adezai bridge	23
A5	After mixing of Culyala Canal	27
A6	At Saradaryab, after mxing of Swat River	33
	NAGUMAN BRANCH	
N3	Naguman branch at Dung Lakhtai	16
N4	Naguman at Naguman bridge	24
N5	After mixing with Akbar Tannery	25
N6	Naguman at Jala Bela	30
	SHAH ALM BRANCH	
S3	Dawnstrem 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 of Kheshki	54
13	Downstream of Sarhad Colony Textile Mill	58
14	Downsteam 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 of Nowshera	65
19	After mixing with Kalpani River at Pirsabak	69
20	After mixing of Akora Kattak sewage drain	76
21	After mixing of Corn Complex sewage drain	86
22	Kabul River at Khairabad	90

Fig. 2: Key to River Sampling Points.

Shah Alam (Fig. 4). This site is just downstream of the highest recorded ammonia level and may be due in part to the nitrification of the ammonia rather than industrial effluent dischargers.

Natural levels of nitrates seldom exceed 0.1 mg/l but when influenced by human activities may contain up to 5 mg/L. Levels in excess of 5 mg/L usually indicate pollution by human or animal waste, or fertilizer run-off. In case of extreme pollution, concentrations may reach 200 mg/L (Chapman, 1992). Nitrate levels in the Kabul river are within the permissible range required for the maintenance of fisheries and aquatic life.

The concentrations of sulfides appear to be very high. the values of < 0.05 mg/L have been shown to cause complete mortality of fish (Anon, 1976). Higher concentrations of sulfide occur at Naguman, Shah Alam and in the lower main river (Fig. 4). However, the pH of the Kabul river water is between 6.5 and 7.8 and Chapman (1992) states that sulfide concentrations need not be considered if the pH is less than 10. This is because at lower pH sulfide exists as non-ionized molecules of Hydrogen sulfide (H_2S) and Hydrosulfide (HS^-), with negligible concentrations of sulfide ions (S^{2-}).

Previous studies have also found high concentrations of sulfides from 0.11 - 1.0 mg/L (Karns, 1977), 0.0 - 2.0 mg/L (Khan et al., 1985) and 0.74 - 1.82 mg/L (Butt, 1989). All researchers have found such levels puzzling, compared to the known inputs of sulfides from pollution sources. Various explanations have been offered including acid waste discharge (Karns, 1977).

Experimental

The whole length of the Kabul river from just above Warsak Dam to its confluence with the Indus at Khairabad was walked between June - August 1993. Samples were collected in polyethylene bottles from 30 points throughout the Kabul river; Fig. 2 shows the locations of the sampling stations. Chlorides sulfates total alkalinity, total hardness, nitrates, nitrites, ammonia, phosphatase, DO, BOD, COD and sulfides were determined by standards methods (APHA, 1985), pH was measured using a portable pH meter (Pye Model - 78) and conductivity by a conductivity meter (Orion Research, Model 1-101).

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.

Conclusion

Two major water quality issued have emerged from this river water survey. These are organic water pollution, particularly in the Shah

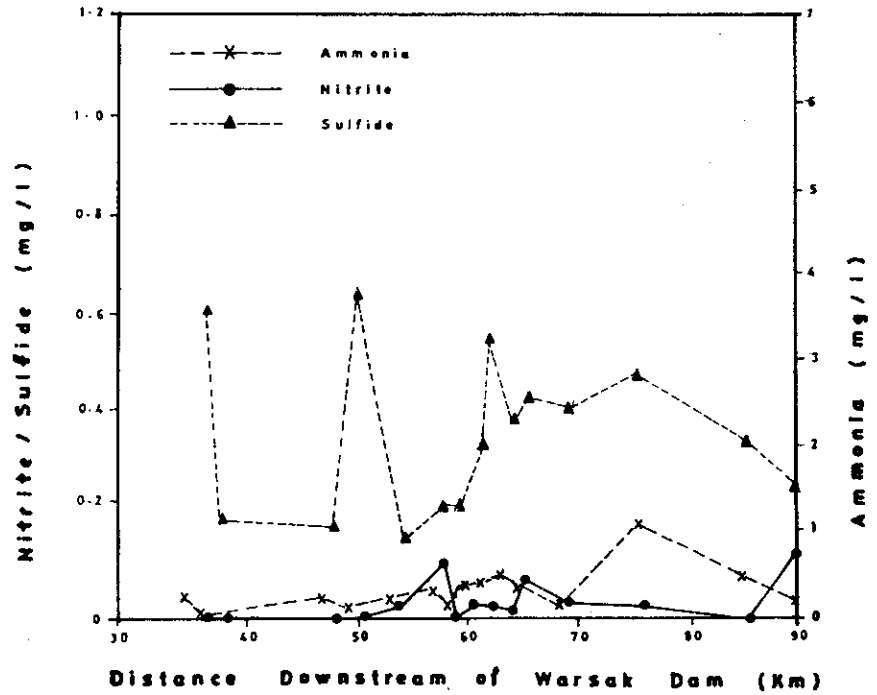

Fig. 4: Ammonia, Nitrite and Sulfide Levels in the Lower Kabul River.

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

Sampling Location	NO_2	NO_3	NH_3-N	PO_4	Cl^-	SO^-_4	S	Alkalinity as $CaCo_3$	Hardness as $CaCO_3$	DO	BOD	COD	pH	Temp. (°C)	Conductivity (μ S cm^{-1})
1	0.000	1.27	0.007	0.00	8	21	0.10	72	83	7.0	0.6	22	7.5	21	185
2	0.000	1.09	0.023	0.00	6	20	0.10	68	83	9.3	0.4	20	7.5	21	185
A3	0.000	1.05	0.028	0.00	8	22	0.10	68	83	7.2	0.6	22	7.7	21	184
A4	0.000	1.87	0.010	0.90	6	25	0.12	72	86	6.9	1.0	12	7.7	22	190
A5	0.000	2.47	0.017	0.71	7	15	0.12	144	160	6.7	1.4	74	7.3	23	324
A6	0.000	1.04	0.032	0.04	6	12	0.16	72	86	7.0	1.6	38	7.5	23	163
N3	0.000	0.57	0.066	0.08	11	26	0.20	73	86	6.6	1.8	10	7.7	25	184
N4	0.000	0.04	0.023	1.19	8	24	0.40	68	82	6.8	1.2	160	7.8	26	182
N5	0.061	0.69	0.042	0.02	16	118	0.60	80	90	6.5	2.0	70	7.8	26	220
N6	0.000	0.82	0.023	0.05	6	24	0.60	64	88	6.7	1.4	63	7.8	27	180
S3	0.000	0.41	0.023	1.19	7	75	0.60	80	90	5.4	2.0	18	7.7	25	188
S4	0.176	0.92	0.046	0.02	10	25	0.40	46	88	5.5	1.8	16	7.7	25	188
S5	0.219	1.39	0.003	0.00	6	14	0.60	84	100	5.5	2.4	46	7.7	26	237
S6	1.016	2.70	0.054	0.00	19	38	0.20	180	179	5.4	3.4	186	7.2	26	527
S7	0.250	0.00	0.125	0.03	14	25	0.38	144	174	5.1	4.8	96	7.4	27	409
8	0.000	1.30	0.261	0.04	12	57	0.60	76	98	6.3	3.0	37	7.8	25	213
9	0.000	1.78	0.021	0.14	9	28	0.16	80	86	6.5	2.2	29	7.6	24	184
10	0.000	1.09	0.247	0.18	18	16	0.16	100	90	6.7	2.0	28	7.7	30	218
11	0.000	1.07	0.092	0.14	13	45	0.60	76	95	6.5	2.4	13	7.7	26	222
12	0.007	1.41	0.247	0.15	13	33	0.16	108	94	6.8	2.0	127	7.6	24	219
13	0.101	1.27	0.321	0.44	17	34	0.20	88	110	5.7	5.0	96	7.4	26	224
14	0.000	1.33	0.205	0.10	10	52	0.20	64	90	5.4	5.2	36	7.6	27	256
15	0.026	1.30	0.267	0.20	14	16	0.32	84	88	6.3	3.0	44	7.7	24	206
16	0.024	1.48	0.331	0.30	20	14	0.56	124	90	6.0	4.1	15	7.6	32	992
17	0.012	1.13	0.443	0.28	11	25	0.34	84	102	5.8	4.3	68	7.6	26	229
18	0.065	1.17	0.270	0.95	12	24	0.40	112	102	5.9	3.2	88	7.5	27	236
19	0.024	1.04	0.162	0.20	16	29	0.36	128	132	5.4	3.9	218	7.7	17	348
20	0.022	1.87	0.988	0.20	11	20	0.44	88	102	5.0	5.1	79	7.7	28	236
21	0.000	1.85	0.517	1.20	38	28	0.34	144	126	6.1	3.4	560	6.5	28	332
22	0.086	2.40	0.210	0.15	16	22	0.24	80	104	6.5	3.0	43	7.7	27	266
Mean	0.070	1.26	0.170	0.30	12	31	0.32	92	103	6.3	2.6	78	7.6	25	265
SD	0.188	0.62	0.206	0.39	6	21	0.18	30	26	0.8	1.4	103	0.2	2.8	155

Alam and lower main river; sulfide concentrations especially in the Naguman and Shah Alam branches and lower main river.

The major sources of organic pollution are the Khazana Sugar Mill, the Ganda Erab and Bundi Nullas carrying sewage from Peshawar. Under low flow conditions it is conceivable that oxygen and ammonia may become critical for fish and indeed fish kills have been observed during the period.

The reason for high sulfide content in the Naguman and Shah Alam branches are mainly the tannery effluents discharged from a number of tanneries situated in the vicinity.

Acknowledgements

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