

# An Assessment of Chemical Pollution in River Kabul and its Possible Impacts on Fisheries\*

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**Abstract.-** Elevated levels of chemical parameters in the river water can be a good indicator of man-induced pollution in the vicinity. Concentrations of BOD, COD, free CO<sub>2</sub>, total hardness, calcium hardness as CaCO<sub>3</sub>, magnesium hardness, total alkalinity, sodium, potassium, ammonia, nitrate, nitrite, chloride, sulphate, phosphate and sulphide were measured using standard methods in water taken along a section of River Kabul receiving untreated city sewage and industrial effluents and compared with water from Warsak Dam being upstream and pristine. A remarkable increase in levels of all the investigated chemical contents confirms the presence of a high level of organic and inorganic pollution in the river adversely affecting the local fish population.

**Key words:** River Kabul, aquatic pollution, effluents, city sewage, organics, contamination.

## INTRODUCTION

**R**iver Kabul originates from Afghanistan and enters Pakistan at Khyber Agency (Gresswell and Huxley, 1965; Fazl-i-Hadi *et al.*, 1988). Warsak Dam is built on River Kabul at Warsak, between Khyber and Mohmand Agencies of Tribal areas in Pakistan (Figs.1, 2). It is hydroelectric powers project, used both for irrigation and electricity production. The dam is without any fish ladder, therefore, is an obstacle for upstream migration of the fish population especially during breeding season which starts in spring and lasts till late summer. The reservoir inhabits almost the same fish population as is found in River Kabul and is used for commercial fishing as well.

About fifty-four fish species have been identified from River Kabul and its tributaries (Rafique, 2001) of which about thirty five are considered as common. The main commercial species are Mahaseer *Tor putitora* (Hamilton, 1822), Mullee *Wallago attu* (Schneider, 1801), Sheermai spp. *Ompok bimaculatus* (Bloch, 1794) and *Ompok pabda* (Hamilton, 1822), Torki *Labeo dyocheilus pakistanicus* (Mirza and Awan, 1976), and Chinese grass carp *Ctenopharyngodon idella*. The catch is

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consumed both locally in villages, and in Peshawar, Charsadda, Mardan, Nowshera, Jehangira and Swabi towns. Many of these fish belong to the carp and *Mystus* families. One species, *Botia rostrata* has only been reported from Pakistan in the River Kabul at Michni (Butt and Mirza, 1981; Butt, 1986).

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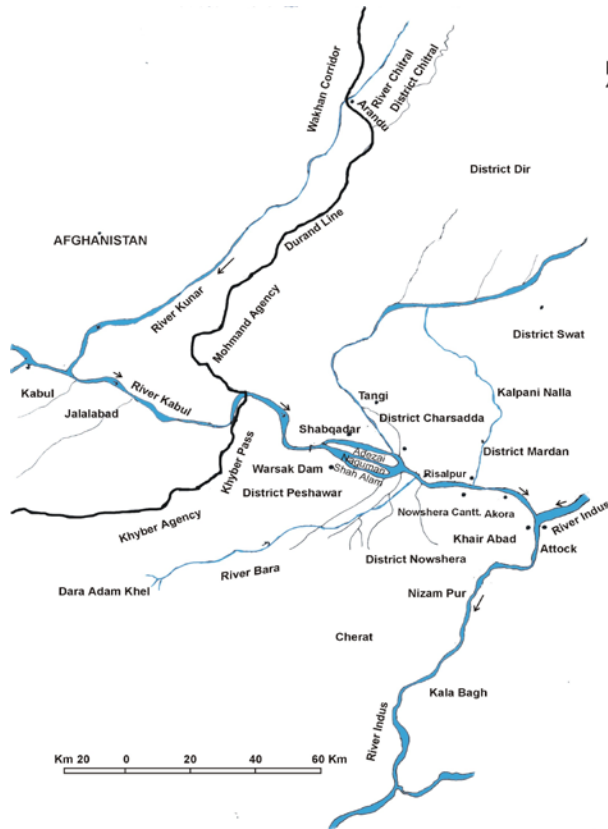


Fig. 1. The River Kabul and its tributaries.

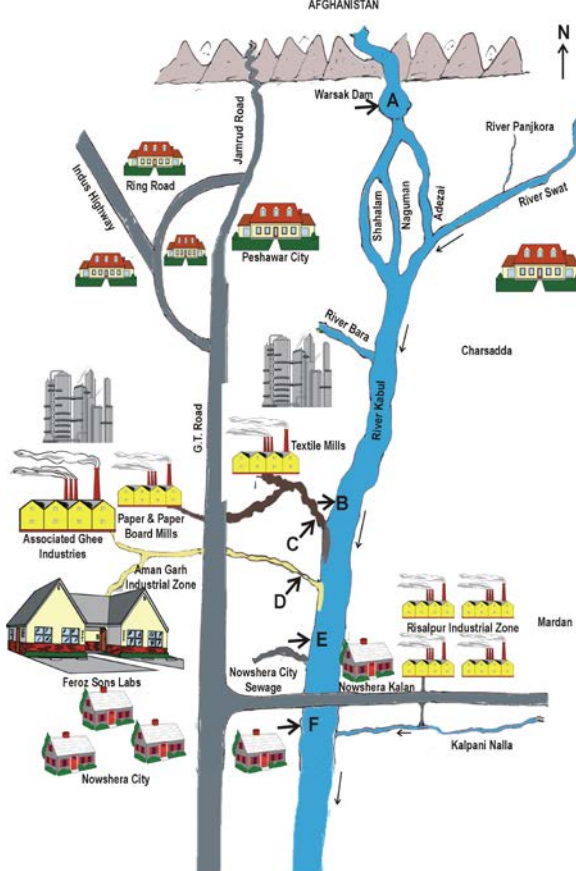


Fig.2. Water sampling points at Warsak Dam (A), main river (B, E, F) and factories' drains (C, D) along River Kabul.

Fig. 2. Water sampling points at Warsak Dam (A) main river (B, E, F) and factories drains (C, D) along River Kabul.

River Kabul and its tributaries are used for commercial as well as sport fishing. The River Kabul and its tributaries transport untreated sewage from the adjoining areas of Swat, Dir, Malakand, Charsadda, Mardan, Peshawar and Nowshera. Peshawar city is close to the Shah Alam branch of River Kabul with a population of more than one million. The lower portion of the river passes through the plains, which are particularly densely populated. Effluents of all of the industries and industrial units situated in the Districts of Swat, Mardan, Charsadda, Peshawar and Nowshera are discharged into River Kabul either directly or indirectly. Of these industries the sugar mills, distilleries, paper mills, tanneries, ghee factories, and textile mills contribute most of the water pollution hazards. It is note worthy that these tributaries also collect different sorts of chemicals such as fertilizers and pesticides from the agricultural fields and ultimately drain them into River Kabul directly or indirectly.

Several cases of the adverse effects of environmental pollution on fish and fish consumers have been reported (Bowen, 1979; Dix, 1981). The annual yield of fish has been observed to be a function of water quality (Owolabi, 1992). Contaminated water not only is a threat for aquatic organisms including fish but is also responsible for transmitting a wide variety of diseases in humans Tebbutt (1983).

To evaluate the quantity of chemical pollution in River Kabul, water samples were taken from different parts of the main river and analyzed for various chemical parameters. The chemical parameters of effluents have been compared with those of the National Environmental Quality Standards (NEQS) and those of downstream river water samples have been compared with control

(Warsak Dam) water comparatively pristine to ascertain the extent of chemical pollution in River Kabul.

## MATERIALS AND METHODS

### *Water samples*

To evaluate the quality and quantity of pollution plug at Nowshera and adjacent Aman Garh, Industrial Area of River Kabul, composite water samples were collected in 3 litre clean, marked, new plastic bottles, thoroughly washed with distilled water followed by washing with the sample water. Sampling was conducted three times a year. Water samples from Main River were collected once in high-flow season in the months of June and July and two times a year in low-flow season in the months of February and December to highlight the effect of water volume on the quantity of water pollution.

Water samples for sulphide were separately collected and their sulphide content was fixed with 1.5 ml zinc acetate solution per liter sample on the spot. All water samples were then stored at 4°C in refrigerator before analyses for various physical and chemical parameters.

### *Sites of water sampling*

Water samples from the following points of the Main River, factory drains and Warsak Dam reservoir were collected (Fig. 2).

### *Water samples from the Main River*

Water samples B, E and F were collected from polluted part of the Main River at Industrial area Aman Garh, Nowshera, at sites B, E, and F. Site B is at the Main River upstream of the effluent discharge into the river, site E is at the Main River downstream of the effluent discharge and site F is at the Main River after city sewage flows into it.

### *Effluent samples*

Effluent samples were collected from factories' drains at Industrial Area Aman Garh, Nowshera at sites C and D. Site C receives effluents from Colony Textile Mills Limited and Sarhad Paper Industries Limited. Site D receives effluents from Ferozesons Pharmaceutical Laboratories and Associated Ghee Mills Limited.

### *Warsak Dam*

Water samples (A) were also collected from Warsak Dam water reservoir constructed on River Kabul in 1960 which is about 60 Km upstream of the polluted part of the River and can be called safe in the sense far away of the dense human and industrial population. This was considered as control sample.

### *Physico-chemical analysis*

Standard methods described in "Standard Methods for the Examination of Water and Wastewater" by the American Public Health Association (APHA, 1985) were followed for the determination of various chemical parameters in water samples. All the reagents used during water analyses were of analytical grade.

Water samples were processed for the estimation of total hardness, calcium hardness, magnesium hardness, alkalinity, sodium, potassium, NH<sub>3</sub>, nitrite, nitrate, chloride, sulfate, phosphate, and sulfide.

Atomic absorption spectrophotometer (model AA-660X V142) was used for the estimation of Na<sup>+</sup> and K<sup>+</sup> in water samples.

Water sample (100 ml) in 250 ml volumetric flask was acidified with 5 ml of HNO<sub>3</sub> (55%) and evaporated on a hot plate to about 20 ml. 5 ml additional HNO<sub>3</sub> (55%), 10 ml perchloric acid (70%) and a few glass beads were added to prevent bumping. The mixture was evaporated until brown fumes change into dense white fumes of perchloric acid (HClO<sub>4</sub>). The sample was removed at this stage from the hot plate, cooled to room temperature and diluted to 100 ml with distilled water in a 100 ml volumetric flask. The solutions were then aspirated into flame atomic absorption spectrophotometer (model AA-660X VI42) for determination of Na<sup>+</sup> and K<sup>+</sup>. Wavelengths set were 589.0 nm for sodium and 766.5 nm for potassium in the presence of air acetylene flame.

### *Statistical analysis*

Student's 't' test was applied for comparison of the data of control with the test samples. Values of P less than 0.05 were considered significant.

## RESULTS

### Warsak Dam upstream water (Sample A=Control)

Tables I and II shows concentrations of chemical pollutants in water samples from Warsak Dam and other collection sites along the river during winter, low flow (Q) and summer, high flow (Q), respectively.

Water sample A (Warsak Dam) (Tables III-IV) had BOD varying between 0.4 and 0.9 mgO<sub>2</sub>/l with 0.72±0.12 mgO<sub>2</sub>/l during low flow (Q) and 0.5±0.1 mgO<sub>2</sub>/l during high flow (Q) season, COD varying between 19 and 23 mgO<sub>2</sub>/l with 22.5±1.05 mgO<sub>2</sub>/l during low Q and 20.3±1.53 mgO<sub>2</sub>/l during

high Q, free CO<sub>2</sub> varying between 1.1 and 2.34 mg/l with 1.64±0.55 mg/l during low Q and 1.16±0.21 mg/l during high, total hardness varying between 79 and 167 mg/l as CaCO<sub>3</sub> with 160.8±4.71 mg/l during low Q and 80.7±2.08 mg/l during high Q, calcium hardness as CaCO<sub>3</sub> varying between 55 and 100 mg/l, with 80.67±4.23 mg/l for low Q and 58±2.65 mg/l for high Q, magnesium hardness varying between 20 and 69 mg/l with 65.67±2.94 mg/l during low Q and 22.67±2.31 mg/l during high Q, total alkalinity varying between 50 and 85 mg/l with 73.2±12.19 mg/l for low Q and 58.67±8.10 mg/l for

**Table I.- Chemical characteristics of water sample A from Warsak Dam (control), water sample B from River Kabul upstream to the confluence point, effluent sample C from Textile and Paper Industries, effluent sample D from Ferozesons Laboratories and Associated Ghee Industries Limited, water sample E from River Kabul downstream to the confluence point and water sample F from River Kabul downstream of E, where city sewage joins the river during low flow (winter) during 1998-2000.**

Parameters (mg/l)	Control A	River B	Effluent C	Effluent D	River E	River F
BOD (mgO <sub>2</sub> /l)	0.72±0.12	3.55±0.36***	290.5±11.8***	280±23.84***	5.6±0.29***	6.5±0.53***
COD (mgO <sub>2</sub> /l)	22.5±1.05	36.67±2.14***	506.2±87.2***	618.8±176.8***	167.8±8.77***	176.48±8.2***
Free CO <sub>2</sub>	1.64±0.55	4.02±0.9***	36.27±3.2***	39.09±2.64***	4.28±0.37***	5.8±0.38***
Total hardness	160.8±4.71	165.4±5.56	480.3±23.9***	389.13±68.4***	175.2±9.26*	182.8±10.7***
Ca hardness	80.67±4.23	101.9±5.85	370.8±49.3***	325.58±69.46***	110.2±15.4*	113.7±11.0**
Mg hardness	65.67±2.94	63.57±8.91	94.45±21.2***	65.22±13.17	69.5±6.72	69.2±7.94
Total alkalinity	73.2±12.19	174.5±51.4***	340.5±65.9***	349.3±56.27***	199.7±45.5***	204.8±4.71***
Na <sup>+</sup>	7.25±1.90	26±1.41***	102.8±8.2***	137.5±15.41***	30.8±3.19***	31.8±1.47**
K <sup>+</sup>	0.9±0.40	3.42±0.41***	18.3±0.8***	18.08±4.94***	6.2±0.15***	6.97±0.43***
NH <sub>3</sub>	0.0018±0	0.36±0.17***	2.98±0.4***	3.18±0.55***	0.51±0.13***	0.81±0.10***
NO <sub>3</sub> <sup>-</sup>	1.07±0.24	1.82±0.14***	0.4±0.5**	0.28±0.10***	1.898±0.11***	1.98±0.03***
NO <sub>2</sub> <sup>-</sup>	0±0	0.01±0.0***	0.08±0.1	0.07±0.06	0.09±0.04***	0.097±0.03***
Cl <sup>-</sup>	7±0.63	20.2±1.47***	36.8±3.9***	238.67±83.5***	23.7±3.02***	24.73±2.70***
SO <sub>4</sub> <sup>2-</sup>	23.83±4.88	71.67±5.20***	513.8±36.5***	141.67±19.2***	177.5±19.6***	220.5±36.2***
PO <sub>4</sub> <sup>3-</sup>	0.07±0.07	0.22±0.04**	2.06±0.4***	2.30±0.38***	0.23±0.04***	0.234±0.04***
Sulphide as S <sup>2-</sup>	0.11±0.03	0.59±0.11***	549.2±37.1***	5.75±0.84***	0.63±0.10***	0.68±0.11***

\* Mean±SD ; Student's t test; \*p<0.05, \*\*p<0.01, \*\*\*p<0.001

\*\* Abbreviations: BOD, biological oxygen demand; COD, chemical oxygen demand; Na<sup>+</sup>, sodium; K<sup>+</sup>, potassium; NH<sub>3</sub>, ammonia; NO<sub>3</sub><sup>-</sup>, nitrate; NO<sub>2</sub><sup>-</sup>, nitrite; Cl<sup>-</sup>, chloride; SO<sub>4</sub><sup>2-</sup>, sulphate; PO<sub>4</sub><sup>3-</sup>, phosphate.

National Environmental Quality Standards (NEQS) for municipal and liquid industrial effluents of Pakistan. Biological Oxygen Demand (BOD) at 20°C for 5 days 80 (mgO<sub>2</sub>/l), Chemical Oxygen Demand (COD) 150 (mgO<sub>2</sub>/l), Chloride as Cl<sup>-</sup>1000 (mg/l), Sulphate as SO<sub>4</sub><sup>2-</sup> 600 (mg/l), Sulphide as S<sup>2-</sup>1.0 (mg/l), Ammonia40 (mg/l).

**Table II.- Chemical characteristics of water sample A from Warsak Dam (control), water sample B from River Kabul upstream to the confluence point, effluent sample C from Textile and Paper Industries, effluent sample D from Ferozesons Laboratories and Associated Ghee Industries Limited, water sample E from River Kabul downstream to the confluence point and water sample F from River Kabul downstream of E, where city sewage joins the river during high flow (summer) during 1998-2000.**

Parameters (mg/l)	Control A	River B	Effluent C	Effluent D	River E	River F
BOD (mgO <sub>2</sub> /l)	0.5±0.1	2±0.36**	295.67±6.66***	281.67±28.3***	4.03±0.35***	5.33±0.49***
COD (mgO <sub>2</sub> /l)	20.3±1.53	43±5**	548.7±129.2**	765±54.08***	71.4±7.09***	80.3±3.06***

Free CO <sub>2</sub>	1.16±0.21	4.88±0.5***	39.97±1.13***	39.97 ±2.00***	3.21±0.26***	3.68±0.15***
Total hardness	80.7±2.08	93±2.65**	460±51.96***	405.67±26.6***	96±1.00***	98±1.00***
Ca hardness	58±2.65	53±2.65*	330.7±53.7***	333±39.34***	57.7±2.08	58.3±2.89
Mg hardness	22.67±2.31	40±0.23**	133±69.48*	74.33±29.02*	38.3±2.89**	39.7±2.08***
Total alkalinity	58.67±8.10	93.3±2.89***	331.7±94.36**	310.67±64.7***	101.6±2.89***	105.3±4.5***
Na <sup>+</sup>	3±1.00	13.8±0.76	103.3±10.41***	126.6±16.07***	13.5±3.04**	15±2.65**
K <sup>+</sup>	1.73±0.32	2.23±0.15	15.67±1.15***	20.1±3.44***	3.57±0.50**	4.1±0.20***
NH <sub>3</sub>	0.01±0.01	0.07±0.14	3.3±0.40***	3.18±0.49***	0.27±0.08**	0.36±0.06***
NO <sub>3</sub> <sup>-</sup>	0.66±0.43	1.04±0.6	0.45±0.07	0.3±0.14	1.08±0.06	1.04±0.10
NO <sub>2</sub> <sup>-</sup>	0±0	0±0	0.06±0	0.07±0.00	0.04±0.01*	0.05±0.01**
Cl <sup>-</sup>	5.67±0.58	13.83±0.8***	31.67±0.58***	260.3±68.19**	17.23±2.04***	18.13±1.4***
SO <sub>4</sub> <sup>2-</sup>	16.6±5.51	32.67±2.5*	501± 113.7**	140.3±27.75**	75.67±4.35***	182.3±4.7***
PO <sub>4</sub> <sup>3-</sup>	0.08±0.01	0.03±0.01**	2.55±0.14***	2.38±0.44***	0.03±0.01**	0.04±0.01**
Sulphide as S <sup>2-</sup>	0.17±0.04	0.29±0.05*	553.3±25.7***	5.66±0.62***	0.32±0.06*	0.39±0.07**

\* Mean±SD ; Student's t test; \*p<0.05, \*\*p<0.01, \*\*\*p<0.001

\*\* See Table I for abbreviations.

**Table III.- Showing X (fold) increase in various parameters at different locations of the river with reference to control sample A (Warsak Dam) during winter (low Q).**

Parameters (mg/l)	Control A	River B	Effluent C	Effluent D	River E	River F
BOD (mgO <sub>2</sub> /l)	0.72±0.12	4.9X	403.5X	388.89X	7.77X	9.03X
COD (mgO <sub>2</sub> /l)	22.5±1.05	1.63X	22.5X	27.50X	7.46X	7.84X
Free CO <sub>2</sub>	1.64±0.55	2.45X	22.1X	23.83X	2.60X	3.53X
Total hardness	160.8±4.71	1.02X	2.99X	2.42X	1.09X	1.13X
Ca hardness	80.67±4.23	1.26X	4.59X	4.03X	1.36X	1.41X
Mg hardness	65.67±2.94	0.96X	1.43X	0.99X	1.05X	1.05X
Total alkalinity	73.2±12.19	2.38X	4.65X	4.77X	2.73X	2.79X
Na <sup>+</sup>	7.25±1.90	3.58X	14.18X	18.96X	4.24X	4.38X
K <sup>+</sup>	0.9±0.40	3.8X	20.33X	20.08X	6.89X	7.74X
NH <sub>3</sub>	0.0018±0	200X	1655.5X	1766.6X	283.3X	450X
NO <sub>3</sub> <sup>-</sup>	1.07±0.24	1.70X	0.37X	0.26X	1.77X	1.85X
NO <sub>2</sub> <sup>-</sup>	0±0	-	8X	7X	9X	9.7X
Cl <sup>-</sup>	7±0.63	2.88X	5.25X	34.09X	3.38X	3.53X
SO <sub>4</sub> <sup>2-</sup>	23.83±4.88	3.0X	21.56X	5.94X	7.44X	9.25X
PO <sub>4</sub> <sup>3-</sup>	0.07±0.07	3.14X	29.42X	32.55X	3.28X	3.28X
Sulphide as S <sup>2-</sup>	0.11±0.03	5.36X	49927X	52.27X	5.72X	6.18X

\* Mean±SD, \*\* See Table I for abbreviations

**Table IV.- Showing X (fold) increase in various parameters at different locations of the river with reference to control sample A (Warsak Dam) during summer (high Q).**

Parameters (mg/l)	Control A	River B	Effluent C	Effluent D	River E	River F
BOD (mgO <sub>2</sub> /l)	0.5±0.1	4X	591.34X	563.34X	8.06X	10.66X
COD (mgO <sub>2</sub> /l)	20.3±1.53	2.11X	27.03X	37.68X	3.51X	3.95X
Free CO <sub>2</sub>	1.16±0.21	4.20X	34.45X	34.45X	2.76X	3.17X
Total hardness	80.7±2.08	1.15X	5.75X	5.02X	1.18X	1.21X
Ca hardness	58±2.65	0.91X	5.70X	5.74X	0.99X	1.00X
Mg hardness	22.67±2.31	1.76X	5.86X	3.27X	1.68X	1.75X
Total alkalinity	58.67±8.10	1.59X	5.65X	5.29X	1.73X	1.79X
Na <sup>+</sup>	3±1.00	4.6X	34.43X	42.2X	0.97X	5.0X
K <sup>+</sup>	1.73±0.32	1.28X	9.05X	11.61X	2.06X	2.37X
NH <sub>3</sub>	0.01±0.01	7X	330X	318X	27X	36X
NO <sub>3</sub> <sup>-</sup>	0.66±0.43	1.57X	0.68X	0.45X	1.63X	1.57X
NO <sub>2</sub> <sup>-</sup>	-	-	-	-	-	-
Cl <sup>-</sup>	5.67±0.58	2.44X	5.58X	45.90X	3.03X	3.19X

SO <sub>4</sub> <sup>2-</sup>	16.6±5.51	1.96X	30.18X	8.45X	4.55X	10.98X
PO <sub>4</sub> <sup>3-</sup>	0.08±0.01	0.375X	31.87X	29.75X	0.375X	0.5X
Sulphide as S <sup>2-</sup>	0.17±0.04	1.70X	3254.7X	33.29X	1.88X	2.29X

\* Mean±SD, \*\* See Table I for abbreviations

high Q, sodium varying between 2 and 10 mg/l with 7.25±1.90 mg/l during low Q and 3.0±1.00 mg/l during high Q, potassium varying between 0.5 and 2.1 mg/l with 0.9±0.40 mg/l during low Q and 1.73±0.32 mg/l during high Q, ammonia varying between 0.002 and 0.02 mg/l with 0.0018±0 mg/l during low Q and 0.01±0.01 mg/l during high Q, nitrate varying between 0.05 and 1.49 mg/l with 1.07±0.24 mg/l during low Q and 0.66±0.43 mg/l during high Q, nitrite was negligible throughout the study at this location, chloride varying between 5 and 8 mg/l with 7±0.63 mg/l during low Q and 5.67±0.58 mg/l during high Q, sulphate varying between 15 and 28 mg/l with 23.83±4.88 mg/l during low Q and 16.6±5.51 mg/l during high Q, phosphate varying between 0.001 and 0.16 mg/l with 0.069 mg/l for low Q and 0.08 mg/l during high Q, sulphide varying between 0.09 and 0.21 mg/l with 0.11±0.03 mg/l during low Q and 0.17±0.04 mg/l during high Q.

All the chemical parameters studied in Warsak Dam water samples, showed values within the permissible limits laid down by the NEQS, highlighting the suitability of the Warsak Dam water for aquatic life including fish.

#### *River Kabul water (Water Sample B)*

The water sample B from River Kabul downstream to Warsak Dam (Tables III-IV) had BOD ranging between 1.60 and 3.9 mgO<sub>2</sub>/l with 4.9 fold increase during low flow and 4 fold during high flow, COD ranging between 34 and 48 mgO<sub>2</sub>/l with 1.63 fold increase during low flow and 2.11 fold during high flow, free CO<sub>2</sub> ranging between 3.2 and 5.2 mg/l with 2.45 fold increase during low flow and 4.20 fold during high flow, total hardness ranging between 90 and 171.9 mg/l with 1.02 fold increase during low flow and 1.15 fold during high flow, calcium hardness as CaCO<sub>3</sub> ranging between 50 and 110 mg/l, with 1.26 fold increase during low flow and 0.91 fold for high flow, magnesium ranging between 40 and 71 mg/l with 0.96 fold during low flow and 1.76 fold during high flow,

total alkalinity ranging between 90 and 250 mg/l with 2.38 fold increase for low flow and 1.59 fold during high flow, sodium ranging between 13 and 28 mg/l with 3.58 fold increase during low flow and 4.6 fold increase during high flow, potassium ranging between 2.1 and 3.9 mg/l with 3.8 fold increase during low flow and 1.28 fold during high flow, ammonia ranged between 0.14 and 0.526 mg/l with 200 increase during low flow and 7 fold during high flow, nitrate ranging between 1.00 and 1.99 mg/l with 1.70 fold increase during low flow and 1.57 fold during high flow, nitrite ranging between 0.009 and 0.021 mg/l with negligible increase during low and high flow, chloride ranging between 13 and 22 mg/l with 2.88 fold increase during low flow and 2.44 fold increase during high flow, sulphate ranging between 30 and 80 mg/l with 3.0 fold increase during low flow and 1.96 fold during high flow, phosphate ranged between 0.03 and 0.24 mg/l with 3.14 fold increase during low flow and 0.38 fold during high flow, sulphide ranging between 0.23 mg/l and 0.74 mg/l, with 5.36 fold increase for low flow 1.70 fold increase for high flow.

Almost all the parameters recorded at this point are showing increasing tendency in comparison with the same parameters of water sample A.

#### *Effluents from Textile and Paper Industries (Water Sample C)*

Effluents (water sample C) from Textile and Paper Industries had BOD ranging between 275 and 304 mgO<sub>2</sub>/l with 403.5 fold increase during low flow (Q) and 591.34 fold increase during high flow (Q), COD ranging between 400 and 636 mgO<sub>2</sub>/l with 22.5 fold increase during low flow and 27.03 fold during high flow, free CO<sub>2</sub> ranging between 25.6 and 41.1 mg/l with 22.1 fold increase during low flow and 34.45 fold increase during high flow, total hardness ranging between 400 and 500.7 mg/l with a 2.99 fold increase during low flow and 5.75 fold during high flow, calcium hardness as CaCO<sub>3</sub>

ranging between 280 and 425 mg/l with 4.59 fold increase during low flow and 5.70 fold during high flow, magnesium hardness ranging between 71 and 210 mg/l with 1.43 fold increase during low flow and 5.86 fold increase during high flow, total alkalinity ranging between 224 and 401 mg/l with 4.65 fold increase during low flow and 5.65 fold increase during high flow, sodium ranging between 94 and 115 mg/l with 14.18 fold increase during low flow and 34.43 fold increase during high flow, potassium ranging between 15 and 19 mg/l with 20.33 fold increase during low flow and 9.05 fold during high flow ammonia ranging between 2.3 and 3.7 mg/l with 1655.5 fold increase during low flow and 330 fold during high flow, nitrate ranging between 0.4 and 1.5 mg/l with 0.37 fold increase during low flow and 0.68 fold during high flow, nitrite concentration ranged between 0.1 and 0.2 mg/l with 8 fold increase during low flow but no change during high flow, chloride ranging between 29 and 40 mg/l with 5.25 fold increase during low flow and 5.58 fold during high flow, sulphate ranging between 395 and 621 mg/l with 21.56 fold increase during low flow and 30.18 fold increase during high flow, phosphate ranging between 1.39 and 2.71 mg/l with 29.42 fold increased during low flow and 31.87 fold during high flow, sulphide ranging between 496 and 575 mg/l with 49927 fold increase during low flow and 3254.7 fold increase during high flow season.

Effluents from Textile and Paper Industries were discharging high organic pollutants load into the river. BOD and COD values were higher than the NEQS recommended values of 80 and 150 mgO<sub>2</sub>/l respectively. Effluents were with high free CO<sub>2</sub>. In general free carbon dioxide in excess of 20 mg/l may be considered lethal for aquatic life. Sulphates present here are high for aquatic system and could be harmful. Sulfide values were very high than the NEQS permissible limit (1.0 mg/l). This shows that these factories are discharging high amount of organic pollutants to the river, which definitely will be harmful for aquatic life.

*Effluents from Ferozesons Laboratories and Associated Ghee Industries Limited (Water Sample D)*

The effluent (sample D) from Ferozesons

Laboratories and Associated Ghee Industries Limited (Tables III-IV) had BOD ranging between 255 and 304 mgO<sub>2</sub>/l with 388.89 fold increase during low flow (Q) and 563.34 fold increase during high flow (Q) season, COD ranging between 445 and 955 mgO<sub>2</sub>/l with 27.50 fold increase during low flow and 37.68 fold increase during high flow, free CO<sub>2</sub> ranging between 35.04 and 42 mg/l with 23.83 fold increase during low flow and 34.45 fold during high flow season, total hardness ranging between 302 and 502 mg/l with 2.42 fold increase during low flow and 34.45 fold during high flow, calcium hardness ranging between 225 and 427 mg/l with 4.03 fold increase during low flow and 5.74 fold increase during low flow, magnesium hardness ranging between 46 and 104 mg/l with 0.99 fold increase during low flow and 3.27 fold during high flow, total alkalinity ranging between 267 and 405 mg/l with 4.77 fold increase during low flow and 5.29 fold during high flow, sodium ranging between 115 and 165 mg/l with 18.96 fold increase during low flow and 42.2 fold during high flow, potassium ranging between 10 and 25 mg/l with 20.08 fold increase during low flow and 11.61 fold during high flow, ammonia ranged between 2.47 and 3.93 mg/l with 1766.6 fold increase during low flow and 318 fold during high flow, nitrate ranging between 0.2 and 0.6 mg/l with 0.26 fold increase during low flow and 0.45 fold during high flow, nitrite ranging between 0.1 and 0.2 mg/l with 7 fold increase during low flow and no change during high flow, chloride ranging between 186 and 401 mg/l with 34.09 fold increase during low flow and 45.90 fold during high flow, sulphate ranging between 115 and 175 mg/l with 5.94 fold increase during low flow and 45.90 fold increase during high flow, phosphate ranging between 1.88 and 2.77 mg/l with 32.55 fold increase during low flow and 29.75 fold during high flow, sulphide ranging between 4.84 and 6.8 mg/l with 52.27 fold increase during low flow 33.29 fold during high flow season.

Effluents were discharging a lot of organic pollutants into the river and were with high BOD, COD, free carbon dioxide and sulfide contents. BOD, COD and sulfide values were higher than the NEQS recommended values of 80, 150 and 1.0 mg/l, respectively.

*Polluted River Kabul water from Site 1 receiving effluents (Water Sample E)*

The water sample E downstream to the confluence point had BOD ranging between 3.7 and 5.9 mgO<sub>2</sub>/l with 7.77 fold increase during low flow and 8.06 fold increase during high flow, COD ranging between 65 and 178 mgO<sub>2</sub>/l with 7.46 fold increase during low flow and 3.51 fold during high flow, free CO<sub>2</sub> ranging between 5.5 and 6.9 mg/l with 2.60 fold increase during low flow and 2.76 fold during high flow, total hardness as CaCO<sub>3</sub> was in the range of 95 and 190 mg/l with 1.09 fold increase during low flow and 1.18 fold during high flow, calcium hardness as CaCO<sub>3</sub> ranging between 56 and 130 mg/l with 1.36 fold increase during low flow and 0.99 fold increase during high flow, magnesium ranging between 35 and 80 mg/l with 1.05 fold increase during low flow and 1.68 fold during high flow, total alkalinity ranging between 100 and 271 mg/l with 2.73 fold increase during low flow and 1.73 fold during high flow, sodium ranging between 10 and 34 mg/l with 4.24 fold increase during low flow and 0.97 fold during high flow, potassium ranging between 3.1 and 6.5 mg/l with 6.89 fold increase during low flow and 2.06 fold during high flow, ammonia ranged between 0.21 and 0.671 mg/l with 283.3 fold increase during low flow and 27 fold during high flow, nitrate ranging between 1.01 and 1.97 mg/l with 1.77 fold increase during low flow and 1.63 fold during high flow, nitrite ranged between 0.03 and 0.09 mg/l with 9 fold increase during low flow and no change during high flow, chloride ranged between 15 and 27.1 mg/l with 3.38 fold increase during low flow and 3.03 fold during high flow, sulfate ranged between 71 and 193.7 mg/l with 7.44 fold increase during low flow and 4.55 fold during high flow, phosphate ranged between 0.034 and 0.261 mg/l with 3.28 fold increase during low flow and 0.38 fold increase during high flow, sulphide ranging between 0.26 and 0.77 mg/l with 5.72 fold increase during low flow and 1.88 fold during high flow.

All the chemical parameters at this point were having values higher than Warsak Dam water samples (control), showing increasing tendency in the amount of pollutants downstream the river. COD during low flow period was higher than the NEQS limit of 150 mg/l. High amount of sulfide was

present in the river.

*Polluted River Kabul water from Site 2 receiving city sewage (Water sample F)*

The water sample F (Tables III-IV) had BOD in the range of 5.0 and 7.4 mgO<sub>2</sub>/l with 9.03 fold increase during low flow and 10.66 fold during high flow season, COD ranging between 77 and 185 mgO<sub>2</sub>/l with 7.84 fold increase during low flow and 3.95 fold during high flow, free CO<sub>2</sub> ranging between 6.8 and 7.9 mg/l with 3.53 fold increase during low flow and 3.17 fold during high flow, total hardness ranging between 97 and 201 mg/l with 1.13 fold increase during low flow and 1.21 fold during high flow, calcium hardness ranged between 55 and 132 mg/l with 1.41 fold increase during low flow and 1.0 fold increase during high flow, magnesium hardness ranging between 38 and 80 mg/l with 1.05 fold increase during low flow and 1.75 fold during high flow, total alkalinity ranging between 101 and 210 mg/l with 2.79 fold increase during low flow and 1.79 fold during high flow, sodium ranging between 12 and 34 mg/l with 4.38 fold increase during low flow and 5.0 fold during high flow, potassium ranging between 3.9 and 7.6 mg/l with 7.74 fold increase during low flow and 2.37 fold during high flow, ammonia ranging between 0.321 and 0.93 mg/l with 450 fold increase during low flow and 36 fold during high flow, nitrate ranging between 1.0 and 1.99 mg/l with 1.85 fold increase during low flow and 1.57 fold during high flow, nitrite ranging between 0.04 and 0.09 mg/l with 9.7 fold increase during low flow and no increase during high flow, chloride ranging between 16.7 and 27.5 mg/l with 3.53 fold increase during low flow and 3.19 fold during high flow, sulfate ranging between 177 and 278 mg/l with 9.25 fold increase during low flow and 1098 fold during high flow, phosphate ranging between 0.035 and 0.038 mg/l with 3.28 fold increase during low flow and 0.5 fold during high flow, sulphide ranging between 0.32 and 0.85 mg/l with 6.18 fold increase during low flow and 2.29 fold during high flow.

All the chemical parameters of the downstream water sample F from River Kabul showed higher values than those of Warsak Dam and water sample E, describing increasing tendency in pollution downstream. COD, BOD, ammonia and



sulfide values were much higher.

Overall results showed that industries in the vicinity are discharging effluents containing high BOD, COD and sulphides into the river.

## DISCUSSION

### *Warsak Dam upstream water (Sample A=Control)*

BOD indicates the amount of biodegradable organics that can deplete oxygen from the existing level of DO. BOD of water is a quantity related to the amount of wastes present. Khan *et al.* (1999a,b) have shown that water containing BOD in the range of 1-3 mgO<sub>2</sub>/l is almost pure. The NEQS maximum permissible limit for this parameter is 80 mgO<sub>2</sub>/l. High BOD is considered threatening for fish. The BOD value at Warsak Dam fell within the range of 0.4-0.9 mgO<sub>2</sub>/l. Thus it is clear that the water is recommendable for fish life with regard to this parameter.

The sulphide concentration higher than 1.0 mg/l can be damaging to the fish, as it adversely affects the fish gills (Khan *et al.*, 1999a,b). The acute toxic effects of hydrogen sulphide cause interference in respiration as well as asphyxiation and death. Early histological symptoms include thickening of the gill epithelium, which lead to reduced permeability to oxygen. This response is typical of any gill irritant and includes increased ventilation and secretion of mucus. Fish may also be observed gasping for air at the surface of the water (South African Water Quality Guidelines, 1996). The concentration of sulphide (0.09-0.17 mg/l) at this location was less than the threshold limit and therefore, it cannot pose any threat to aquatic life.

The data suggest that the reservoir water is safe and quiet fit for inhabitant aquatic life. No organic pollutant was detected. Warsak Dam has been built in the tribal areas, far away from the industrial activities and human population.

### *River Kabul water (Water Sample B)*

All the parameters at this location of the river show increasing tendency when compared to Warsak Dam water samples. This water sampling point was 55 km downstream from Warsak Dam and half a km upstream from the confluence point at Aman Garh Nowshera. On downstream journey

from Warsak Dam the river passes through a number of villages and the city of Peshawar, therefore city sewage and effluents from many factories and mills and other installations in the vicinity of River Kabul and its tributaries mentioned earlier also joins the river. Moreover, dirty water of River Bara (IUCN, 1994) also joins the river on the way downstream; therefore it is obvious that the water quality of the river would deteriorate downstream.

### *Combined effluents from Textile and Paper Industries (Sample C)*

Effluents from Textile and Paper Industries were discharging high organic pollutants load into the river. BOD and COD values were higher when compared with NEQS recommended values. Mean value for BOD for winter was 290.5±11.81 mgO<sub>2</sub>/l and during summer this value was 295.67±6.66 mgO<sub>2</sub>/l. Both the values were too higher as compared with the NEQS recommended value of 80 mgO<sub>2</sub>/l. Similarly mean value for COD in winter was 506.2±87.24 mgO<sub>2</sub>/l, while during summer this value was 548.67±129.22 mgO<sub>2</sub>/l. Both the values were again higher than the NEQS value of 150 mgO<sub>2</sub>/l. Previously Akif *et al.* (2002) have reported 4160 mgO<sub>2</sub>/l COD value for these effluents. The difference in COD value definitely will be because of difference in mills activities. Effluents were with high free CO<sub>2</sub> mean values. These values were 36.27 mg/l for winter and 39.97 mg/l for summer. In general free carbon dioxide in excess of 20 mg/l may be considered lethal for aquatic life (Ali, 1993). Similarly, sulphates value were less than the NEQS recommended value (600 mg/l) but are high and could be harmful. Sulfide values were very high than the NEQS permissible limit of 1.0 mg/l. These high sulfides have probably enhanced the sulfide level in the river. This shows that these factories are discharging high amount of organic pollutants into the river, which will definitely prove harmful for aquatic life.

### *Combined effluents from Ferozesons Laboratories and Associated Ghee Industries Limited (sample D)*

Effluents were discharging high organic pollutants into the river and were with high BOD, COD, free carbon dioxide and sulfide contents.

BOD, COD and free CO<sub>2</sub> being high enough can cause depletion in oxygen level in the river water. Surface waters normally contain less than 10 ppm free carbon dioxide. Larger quantities, however, have detrimental effect. High concentrations of carbon dioxide accompanied with low concentration of oxygen are toxic to fish. In general free carbon dioxide in excess of 20 ppm is considered lethal (Ali, 1993). Sulfides mean values were 5.75 mg/l and 5.67 mg/l, respectively for winter and summer and are again higher than the NEQS limit of 1.0 mg/l.

However, pollutants concentration in the effluents could be variable, because of change in the activities, quality and quantity of products, and priorities in products. Previously discharge of effluents, rich in various pollutants, by the fore said industries, have also been reported by some workers including Karns (1977) and IUCN (1994).

#### *Polluted River Kabul water, Site 1 (receiving effluents)*

This was the site from where fish sample 1 was collected. Comparing the data with the control (Warsak Dam) it is clear that a considerable increase in pollution have occurred. Most of the parameters have increased, showing the signs of increased localized pollution in the river, most probably caused by the effluents.

The most interesting parameter was COD. This parameter throughout low flow sampling showed values (168 mg/l, 160 mg/l, 155 mg/l, 178 mg/l and 172 mg/l) even higher than the value of 159 mg/l recommended by the NEQS for effluents. While during low flow its mean value (71.4±7.09) was within the limits for effluents but can be considered high for productive rivers like River Kabul. COD determine oxygen consumed (APHA, 1955). Both the BOD and COD are considered to be causing oxygen depletion in the water. Dissolved oxygen is labile and can easily be reduced by carbon compounds to form carbon dioxide. Heating of water also lowers the solubility of oxygen and reduces the DO concentration. The DO concentration of water is strongly affected by the presence of oxidisable matter and as such, is affected by the dissolved organic carbon (DOC), the biochemical oxygen demand (BOD) and organic

and inorganic nitrogen concentrations. Other factors that also affect the DO concentration are temperature and pressure. Increasing the DO concentration in aquaculture systems increases the carrying capacity of ponds or fish tanks (South African Water Quality Guidelines, 1996). For best growth, the oxygen level should be above 5 mg/l. Less than 3 mg/l of dissolved oxygen is considered lethal for most of the organisms including fish (Ali, 1993). Although COD reported at this station in the main river is higher than the NEQS limits but has not caused a drastic change in the dissolved oxygen concentration. The reason could be effective aeration of the river water. This can be noted by the increase in DO level as the water passes over Warsak Dam and secondly through the consistent turbulent aerial oxygen remixing resulting in raised values (IUCN, 1994).

Ammonia is extremely toxic to fish and should be present below 0.2 mg/l. Values above 2 mg/l are usually an indication of serious organic pollution (Chapman, 1992). According to this criteria river water at this spot seems to be highly poor regarding low flow mean value of 0.51 mg/l at this station. Ammonia may be oxidized in aerobic conditions to nitrite and eventually nitrate, which is significantly less toxic to aquatic life. 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). Natural levels of nitrates seldom exceeds 0.1 mg/l but when influenced by human activities may contain up to 5 mg/l. level in excess of 5 mg/l usually indicate pollution by human or animal wastes or fertilizer run-off. In cases of extreme pollution concentrations may reach 200 mg/l (Chapman, 1992).

Sulfide though was below the maximum limit of 1.0 mg/l prescribed by the NEQS but, mean value for low flow period 0.63 mg/l and the maximum recorded values during low flow period 0.66 mg/l, 0.79 mg/l, 0.77 mg/l showed high amount of sulfides present in the river. Sulphide values greater than 0.05 mg/l have caused complete mortality of fish (Anon, 1976). Looking into the results most of the low flow values crosses these limits, but still the fish survives in the river. According to Chapman (1992) sulphide concentrations may not be of great importance if the pH is less than 10. Luckily River

Kabul pH falls below 10. This is because at low pH sulphide exists as non-ionized molecules of hydrogen sulphide ( $H_2S$ ) and hydrosulphide ( $HS^-$ ), with negligible concentrations of sulphide ions ( $S^{2-}$ ).

*Polluted River Kabul water, Site 2 (downstream to site 1, where city sewage joins the river=Water sample F)*

At this point Kalpani nalla joins the river on the opposite side. The quantity of water downstream of this point is considerably deteriorated (IUCN, 1994; Khan *et al.*, 1999a,b).

Increase and decrease in various parameters of limnological importance occurred in the chemical parameters at this point are compared with the control (Warsak Dam).

All the chemical parameters increased considerably, while a decrease in free carbon dioxide occurred. Increase is more conspicuous during low flow when the water volume squeezes, while the increase is comparatively less during high flow because of dilution (Tables I-IV).

Overall results show that industries in the vicinity are discharging effluents containing high BOD, COD and sulphides into the river. Levels of these parameters were exceeding the NEQS permissible limits for effluents. Effluents are thus causing both organic and inorganic pollution in the river.

During low flow period in winter because of less snowmelt at the top of the hills, the river water volume reduces about three times, but the effluents and sewage concentration remains the same. In summer during high flow period, snow melts at the top of the hills and results in flooding and hence in an increase in the river volume, which dilutes the pollutants in the river in these months.

Some of the parameters like COD and sulphides, in the downstream river water exceed the NEQS permissible limits during low flow period. This study confirms that the river has become polluted downstream the Warsak Dam and that there is localized pollution in vicinity of Nowshera. Similar reports regarding River Kabul pollution is also been reported in the past (Karns, 1977; Akif and Khattak, 1990; IUCN, 1994; Khan *et al.*, 1999a,b). This pollution plug might be preventing the fish from their natural phenomenon of migration

to and from the mighty River Indus, which have definitely played a role in reduction in whole fish population in general and *Tor putitora* in particular, which is considered as clean water lover and breeds in very clear waters. Moreover, this pollution will be lethal to eggs and juveniles as compared to adults, and there is the sure danger of a definite loss of fish seed and grown up fish.

## CONCLUSIONS

1. The industries in the vicinity of River Kabul discharge their effluents containing high BOD, COD and sulphides into the River Kabul, thus raising the levels of these parameters beyond the recommended levels of National Environmental Quality Standards (NEQS).
2. Some of the parameters like COD and sulphides remain higher in the downstream river water showing sublethal pollution.
3. The decline in fish population and especially that of Mahaseer, *Tor putitora* in River Kabul can not only be attributed to detrimental effect on adult fish growth but also on fish eggs and seeds.
4. The data also confirms the presence of pollution plug in the river at Nowshera, which has created a barrier between the fish populations of River Indus and River Kabul. The migration of Mahaseer, *Tor putitora* from River Indus into spawning areas in River Kabul during breeding season has also stopped which is another reason for decline of *Tor putitora* population in River Kabul and also in River Indus.

## RECOMMENDATIONS

1. The processing of industrial effluents, before their disposal should be regulated.
2. Environmental laws should be implemented and public awareness should be created.
3. A general biomonitoring program is needed to be established.
4. The construction of Warsak Dam on River Kabul without fish ladder has also limited the Mahaseer population into two zones that is

Pakistan and Afghanistan. This Dam has blocked the migration of Mahaseers from Pakistan to breeding areas in Afghanistan. Construction of fish ladder in Warsak Dam could be helpful in the natural propagation of the fish population.

5. Illegal and indiscriminate fishing, even during spawning season, is another reason of fish decline. As this practice is not only harming the adult population but is also destroying fish seed. Strict supervision by supervisory staff and social awareness is highly needed.
6. Use of brutal means for fishing like electric currents, dynamite and addition of chemicals are also in practice in various parts in vicinity of the River Kabul and its tributaries. This practice is destroying fish population and its seeds and is even detrimental for men consuming chemicals baited fish.

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