Pollution Studies of Kabul River and its Tributaries for the Assessment of Organic Strength and *Fecal Coliform*

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Summary: Thirty eight samples of water from Kabul River and its tributaries starting from Warsak Reservoir to the confluence point of Kabul and Indus Rivers covering a stretch of about 90 km and the waste water being discharged by different drains into the river were collected systematically and analysed for total organic strength as Chemical Oxygen Demand (COD) and degradable organics as Biological Oxygen Demand (BOD) using standard methods. River water samples from different locations were also analysed bacteriologically for *Fecal coliforms*. All the waste water samples and river water at a few locations were found to be high in COD, BOD and *Fecal coliform* rendering it unfit for irrigation and human consumption. The results also suggest that the effluents from Khazana Sugar Mills, Colony Sarhad Textile Mills, Amarjee Paper and Paper Board Mills and from different tanneries are the main sources of organic pollution in the Kabul River. Reduction in fish crop in Kabul River could be referred to the increased organic pollution.

Introduction

Kabul River and its tributaries provide water for irrigation, fish crop and recreation. The fish crop from this river has been an important source of proteinous food. It has been reported [1] that the discharges of industrial effluents in Kabul River have resulted in marked fall in fish population. The villagers living at the river banks have also been complaining about the pollution, which is very obvious and has often resulted in periodic fish kills [1]. However, very little data is available on the distribution of fish in the Kabul River [2] but presence of fish throughout the stretch of river is an evidence that river is not biologically dead any where [3].

Unfortunately with the setting up of industries at Amangarh near Nowshera in the mid 1950s and afterwards the river provided an easy mean of waste dumping. Since then the industrial effluents and solid waste of the surrounding industries and villages have been disposed off into Kabul River. As a result, the local fish fauna have started declining. It has also been reported [3] that there are eight industrial units directly discharging their effluents into the main Kabul River and its branches. Numerous other small industries are also discharging wastes into channels and drains which eventually end up in the river. These effluents as a group are diverse in nature. Spent sulphite liquor, spent mineral acids, sulfides, oxidizable compounds etc. from the industries like; paper, chemicals, soap, textile, pharmaceutical, sugar and tanneries are mainly responsible for creating aquatic pollution in Kabul River. Some of these effluents are toxic in nature while other have hazardous effect on aquatic life.

These studies are aimed to pin point the locations and the industries whose effluents are causing pollution in the Kabul River, and to determine the extent of pollution with special emphasis on the organic wastes in the river and its evaluation for human use. Khan *et al.* [1] and Karns [4] have provided some base line data, yet the data were not sufficient enough to give an estimate of organic strength and *Fecal coliform* of the Kabul River. However, the preliminary studies [4] have generally indicated considerable pollution both in this river and its tributaries during the winter season. This was later confirmed and was correlated with the quantity and flow of water in the river which recedes considerably during winter [3].

The main industries discharging their effluents into Kabul River and its tributaries are listed below:

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Industrial units within the project area

1. Amarjee Chemical Works and Paper Board, Nowshera.
2. Feroz Sons Pharmaceutical Labs. and Soap Factory, Nowshera.
3. Colony Sarhad Textile Mills, Nowshera.
4. Associated Industries, Nowshera.
5. Tanneries, across the Railway Bridge Nowshera.
6. Peshawar Tanneries Ltd., Charsadda Road Near Shah Alam Bridge.
7. Tooti Tanneries, Ltd., Charsadda Road Near Shah Alam Bridge.
8. Few Leather Industries at Charsadda Road.
9. Charsadda Tanneries Charsadda.
10. Charsadda Sugar Mills Charsadda.
11. Pakistan Paper Corporation Ltd. Charsadda.
12. Khazana Sugar Mills, Peshawar.

Sampling

Representative samples were collected in clean polythene bottles starting from upstream of Warsak Dam and ending at the confluence of Kabul and Indus rivers including major tributaries and effluent/municipal waste drains (Figure 1). Collection points varied from 100 meters to 1 km from the confluence of drain and the river.

Results and discussion

Chemical oxygen demand

The chemical oxygen demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant [5,6]. For sample from a specific source COD can be related empirically to BOD, organic carbon, or organic matter. The test is useful for monitoring and control after correlation has been established [7].

A total of 38 samples were collected from the Kabul River and its tributaries for COD examinations. The locations of sampling points are shown in Figure 1 and the results are summarised in Table 1. COD ranges from 2.20 mg O_2/l at Warsak Reservoir upstream of Warsak Dam to 10098.82 mg O_2/l in the effluent of Khazana Sugar Mills. The

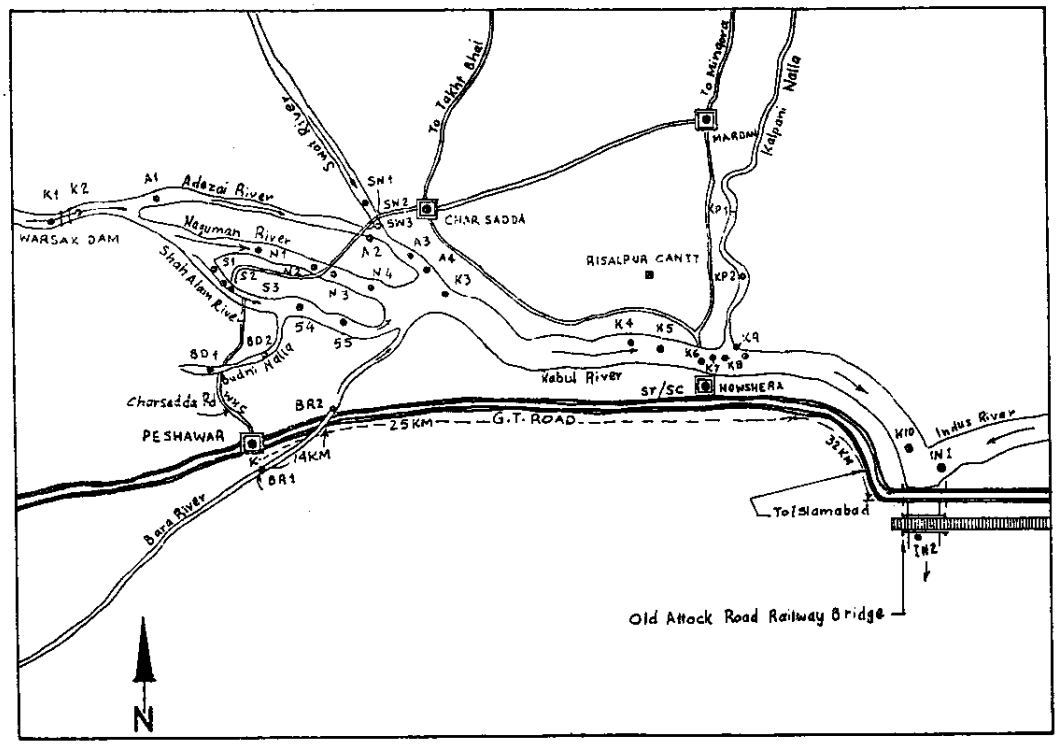

Fig. 1: Location of sampling site.

COD value decreases 5 km downstream of the reservoir. However, this value increases at Hindko Daman village due to the entry of Budni Nalla and Ganda Erab which are the main sewage carriers of Peshawar City. The COD values are generally higher under low flow condition [8]. The available literature suggests permissible limit of COD as 4 mg O_2/l [6] as laid down by the United States Public Health Drinking Water Standards. Pakistan's NEQ standard [9] for COD fixed for industrial effluents is 150 mg/l. Five out of 38 samples of river and waste water have COD values from 2 to 4 mg/l indicating its suitability for human consumption provided other parameters are within the threshold limits.

The combined effluent being discharged in a single drain by Amarjee Paper and Paper Board Mills, Sarhad Colony and Colony Sarhad textile Mills (ST/SC) had a high COD (1426.04 mg O_2/l) which is over nine times higher than the permissible limit (150 mg O_2/l COD) [9]. Earlier studies [10] undertaken in this regard at this location also suggest that Colony Sarhad Textile Mills is discharging large volume of objectionable liquid waste having several folds higher COD than the permissible limits into Kabul River which have deleterious effects on the quality of river water. Another study (unpublished data) has shown COD values of this combined drain as 2510 mg O_2/l in autumn, 1963.87 mg O_2/l in winter, 778.80 mg O_2/l in spring and 1875.0 mg O_2/l in summer. These values indicate the persistent organic pollution 5 to 17 times higher than the permissible limit each year. However, organic strength in the downstream sample (K-5) decreased to 47.16 mg O_2/l which is obviously due to dilution. Keeping in view the overall COD level in the river water this value can not be overlooked for the fish crop. The black liquor of the paper mills being discharged in the combined drain contains lignosulphonates which have been reported to be detrimental to fish population [11]. Similar trend is seen in the effluent sample (AK) from Akbar Tannery at the Charsadda road and the downstream sample from this tannery (N-3), where COD values decreased from 1363.80 to 25.46 mg O_2/l. The presence of high oxidizable material in the effluent (KS-1) discharged into Kabul River by Khazana Sugar Mills is alarmingly high (10098.82 mg O_2/l) and can be termed as the major single source of organic pollution. Sugar Mills effluent which is providing a rich source of easily degradable organic nutrients (BOD 7700.0 mg O_2/l - Table 1) may encourage the growth of the possible pathogenic bacteria present in human excreta. Thus the sewage containing human excreta being discharged in combination with the industrial effluent in a single drain may pose a serious threat to consumers whether this water is utilized directly or indirectly. The higher values (920000/100 ml) of *Fecal coliform* (Table-2) at this point substantiates this statement.

Although the general COD level in the Kabul River remained in the range 2-20 mg O_2/l, the downstream sample NS inspite of dilution show higher organic pollution (57.41 mg O_2/l) which demonstrates poor quality of river water at this point. The organic strength at BD-2 being the upstream of Shah Alam River with 25.74 mg O_2/l increased to 45.54 mg O_2/l at S_3-1 near Shah Alam bridge on Charsadda Road. This increase is due to the addition of different municipal and industrial wastes all along its course of flow.

Biological oxygen demand (BOD)

Although, this is an empirical, semi-quantitative method based on oxidation of organic matter by suitable aquatic micro-organisms during a 5 days period [6], still it gives us an estimate of biodegradable organic compounds present in a sample. In other words, BOD of water is a quantity related to the amount of wastes present. Water sample containing BOD in the range 1-3 is considered to be fairly pure. However, its purity becomes doubtful when the BOD value reaches 5 mg/l [12]. The permissible limit of BOD for industrial effluents is 80 mg O_2/l [9]. No threshold limit of BOD is available for water bodies and for the sustenance of aquatic life.

The results in Table 1 indicate BOD of Kabul River and its tributaries varying in the range 0.4-7700 mg O_2/l. The BOD level in the River Kabul from Warsak to the Indus ranges from 0.9 mg O_2/l at Warsak (K-1) to 4 mg O_2/l at Khairabad Kund (K-10) which seems to be within the permissible limits. There is an exception at the downstream of Colony Sarhad Textile Mills where the BOD was found to be 18.5 mg O_2/l. This is the only reach of

Table 1: Results of water and waste water samples

S. No	*Sample No.*	Sample Location	*BOD (mg O_2/L)	**COD (mg O_2/L)
1.	K-1	Warsak Reservoir upstream of Warsak Dam	0.9±0.1	2.00±0.05
2.	K-2	Kabul River downstream of Warsak reservoir	0.8±0.1	7.27±0.12
3.	K-3	Kabul River after mixing of Naguman River	1.1±0.2	9.09±0.13
4.	K-4	Kabul River upstream of Sarhad Colony Textile Mills	0.4±0.1	5.00±0.08
5.	A-1	Adezai River at midrine bridge	1.8±0.1	4.00±0.10
6.	A-2	Adezai River before mixing of Swat	1.0±0.2	2.00±0.03
7.	A-3	Adezai River at Sardaryab River after mixing of Swat River	1.2±0.2	5.00±0.07
8.	A-4	Adezai River before mixing of Naguman River	0.7±0.1	2.00±0.04
9.	K-5	Kabul River downstream of Sarhad Colony Textile Mills	18.5±0.8	47.16±0.53
10.	K-6	Kabul River upstream of Nowshera Sewage drain	2.0±0.1	9.43±0.09
11.	K-7	Kabul River downstream of Nowshera Sewage drain	7.0±0.2	18.86±0.19
12.	K-8	Kabul River upstream of Kalpani Nullah at Pir Sabak	5.0±0.2	11.32±0.09
13.	K-9	Kabul River downstream of Kalpani Nullah at Pir Sabak	4.0±0.1	7.55±0.11
14.	K-10	Kabul River before joining Indus at Kund	4.0±0.1	20.00±0.21
15.	IN-1	Indus before mixing Kabul River	2.5±0.1	18.18±0.18
16.	IN-2	Indus River after mixing with Kabul River	0.5±0.1	16.37±0.14
17.	BD-1	Budni Nullah- Nullah bridge 9 Km from Peshawar on Charsadda road	3.3±0.2	16.83±0.15
18.	BD-2	Budni Nullah 3 Km off Charsadda road-upstream of Shah Alam River near village Hindko Daman	14.1±0.4	25.74±0.32
19.	S-1	Shah Alam River upstream of Khazana Sugar Mill effluent drain	4.5±0.4	10.89±0.10
20.	S-2	Shah Alam River downstream of Khazana Sugar Mill effluent drain	1.8±0.1	7.92±0.11
21.	S-3	Shah Alam River on Charsadda road bridge (11 Km off Peshawar)	1.2±0.1	8.91±0.04
22.	S-5	Shah Alam River 1 Km upstream off Dalazak road (bridge on Mian Gujar Road)	5.0±0.1	13.86±0.10
23.	N-1	Naguman River (8 Km upstream of Naguman River bridge on Charsadda road) near Miskeen Abad /Dung Lakhtai	2.6±0.1	9.09±0.08
24.	N-2	Naguman River bridge on Charsadda road	1.0±0.1	11.82±0.12
25.	N-3	Naguman River downstream of Akbar Tannery (1 Km downstream of N-2)	7.8±0.5	25.46±0.29
26.	N-4	Naguman River bridge-II (5 Km downstream of Adezai bridge on Mian Gujar-Dalazak road)	0.9±0.1	13.64±0.11
27.	SW-1	Swat River 1 Km downstream of Swat River bridge on Charsadda road	0.5±0.1	9.09±0.08
28.	SW-2	Swat River bridge on Charsadda road	1.6±0.1	14.55±0.13
29.	AK	Effluent from Akbar Tannery located on Charsadda road	720.0±4.5	1363.80±3.16
30.	BR-1	Bara River on Chamkani bridge -9 Km from Peshawar	4.4±0.2	16.37±0.15
31.	BR-2	Bara River on G. T. road bridge near Tarnab Farm-14 Km from Peshawar	1.6±0.1	2.78±0.02
32.	KP-1	Kalpani Nullah near Ghalla Dher (21 Km from Nowshera-Mardan bridge)	2.8±0.1	6.50±0.03
33.	KP-2	Kalpani Nullah near Risalpur (1 Km from Risalpur on Jehangira road)	3.3±0.1	10.19±0.09
34.	NS	Nowshera Sewage 200 m downstream of G. T. road bridge - 2 Km downstream of Nowshera-Mardan bridge	39.0±1.1	57.41±0.65
35.	ST/SC	Sarhad Colony/ Sarhad Textile Mills/Amarjee Paper & Paper Board Mill effluent	615.0±14.3	1426.04±4.11
36.	KS-1	Khazana Sugar Mills effluent	7700.0±57.2	10098.82±14.19
37.	S_3-1	Shah Alam River at Shah Alam bridge on Charsadda road	36.0±1.2	45.54±0.42
38.	S_4	Shah Alam River downstream of Budni Nullah confluence point near Hindko Daman village	7.4±0.5	18.81±0.20

* Biochemical Oxygen Demand
** Chemical Oxygen Demand

the river where the signs of pollution are visible. Previously, localized pollution within 0.5 km has been noted in the downstream of Kabul River due to discharges of effluents from various industries at Amangarh, Nowshera (unpublished data). BOD in the effluents from Khazana Sugar Mills (KS-1), Akbar Tannery (AK) and Colony Sarhad Textile Mills/Paper and Paper Board Mills (ST/SC) is 7700.0, 720.0 and 615.0 mg O_2/l respectively. These are the industries whose effluents are the main sources of organic pollution, deteriorating the overall quality of the river water by depleting the dissolved oxygen in the surrounding water causing suffocation to aquatic life. However, others like, NS (39 mg O_2/l) and S_3-1 (36 mg O_2/l) having comparatively lower adverse effect on the quality of river water, can

Table 2: Results of *Fecal coliform* of water and waste water samples

S.No	*Sample No.*	Sample Location	*Fecal coliform* (*MPN/100 ml)
1.	K-1	Warsak Reservoir upstream of Warsak Dam	1700
2.	K-2	Kabul River downstream of Warsak reservoir	1400
3.	K-3	Kabul River after mixing of Naguman River	1100
4.	A-1	Adezai River at midrine bridge	800
5.	A-3	Adezai River at Sardaryab River after mixing of Swat River	200
6.	K-5	Kabul River downstream of Sarhad Colony Textile Mills	240000
7.	K-7	Kabul River downstream of Nowshera Sewage drain	240000
8.	K-9	Kabul River downstream of Kalpani Nullah at Pir Sabak	110000
9.	K-10	Kabul River before joining Indus at Kund	24000
10.	IN-1	Indus before mixing Kabul River	400
11.	IN-2	Indus River after mixing with Kabul River	24000
12.	BD-2	Budni Nullah 3 Km off Charsadda road-upstream of Shah Alam River near village Hindko Daman	350000
13.	S-1	Shah Alam River upstream of Khazana Sugar Mill effluent drain	140000
14.	KS	Khazana Sugar Mills effluent drain	920000
15.	S-3	Shah Alam River on Charsadda road bridge (11 Km off Peshawar)	23000
16.	S-5	Shah Alam River 1 Km upstream off Dalazak road (bridge on Mian Gujar road)	280000
17.	N-1	Naguman River (8 Km upstream of Naguman River bridge on Charsadda road) near Miskeen Abad /Dung Lakhtai	800
18.	N-3	Naguman River downstream of Akbar Tannery (1 Km downstream of N-2)	3300
19.	N-4	Naguman River bridge-II (5 Km downstream of Adezai bridge on Mian Gujar-Dalazak road)	Nil
20.	SW-1	Swat River 1 Km downstream of Swat River bridge on Charsadda road	Nil
21.	BR-2	Bara River on G. T. road bridge near Tarnab Farm-14 Km from Peshawar	130000
22.	KP-2	Kalpani Nullah near Risalpur (1 Km from Risalpur on Jehangira road)	8000
23.	NS	Nowshera Sewage 200 m downstream of G. T. road bridge - 2 Km downstream of Nowshera-Mardan bridge	2400000

MPN: Most probable number

not be ignored. The NEQ standard [9] has been set for 10 times dilution of an industrial effluents that should at least occur in water bodies. As the dilution factor in Kabul River is many folds higher than this value therefore 39 and 36 mg O_2/l values are very high compared to 10 times diluted value of BOD which comes to 8 mg O_2/l.

Fecal coliform

According to WHO standards [13] satisfactory drinking water should contain not more than 3 coliform per 100 ml, and water with more than 10 per 100 ml is unsatisfactory. Sterritt and Lester [14] have quoted the categories of water quality in a distribution system that water with zero total *coliform* count per 100 ml would be considered excellent and 1-3 cells of *coliform*/100 ml to be satisfactory. 4-9 cells/100 ml have been termed as intermediate whereas, total *coliform* with 10 or more cells per 100 ml is unsatisfactory for human consumption. However, water with even 1 cell of *Fecal coliform*/100 ml is absolutely undesirable for human consumption [7]. *E. coli* should remain

absent upto intermediate category. According to a report [15] more than one thousand *Fecal coliform*/100 ml make a water unfit for irrigation. As indicated in Table 2, 14 out of 19 river water samples contained more than 1000 *Fecal coliform*/100 ml which makes this river water unfit for irrigation in those areas. Samples BD-2, KS and NS were from effluent drains which are not being directly used for irrigation purposes. Samples A-1, A-3, IN-1, N-1, N-4 and SW-1 have zero to 800 *Fecal coliform*/100 ml and are thus within the threshold limits for irrigation. Sample NS (Nowshera sewage) is the worst with respect to *Fecal coliform* which add 2400000 cells/100 ml. This is the highest value determined in all the effluent/sewage samples. This may become a detrimental source of disease causing bacteria in this part of the river. This may also hamper irrigation and recreation. This discussion depicts that the river water at various places can neither be considered safe for human consumption nor for irrigation purposes.

Experimental

Standard methods [5] were used for the measurement of organic strength (BOD and COD) of water and waste water. All the reagents used were of AnalaR grade. Open reflux method was used for the determination of COD. BOD was calculated after measuring dissolved oxygen (DO) level of sample using BOD bottles before and after incubation at 20 ° C for five days. Average values for BOD and COD with standard deviations were recorded as the analyses were carried out in replicates. DO was measured with DO meter model OXI 57 Germany. BOD water was used for dilution wherever required. Several dilutions were made and the diluted samples were incubated. Multiple tube fermentation technique was employed for the assessment of *Fecal coliform*. Presumptive test followed by confirmatory test for *Fecal coliform* was used and the most probable number (MPN) of the fecal bacteria in 100 ml of sample was reported in accordance with the standard method [5].

Conclusion

From these investigations it is concluded that the industrial effluents and sewage have the most significant impact upon the river water quality as both the waste waters are of the poorest quality. The presence of high *Fecal coliform* in the river especially at the downstream of the Colony Sarhad Textile Mills Nowshera due to the sewage drain makes the Kabul River water absolutely unfit for drinking and recreational use unless proper treatment is made prior to consumption.

Shah Alam River is a severely polluted tributary due to high *Fecal coliform* and higher BOD values. The industrial effluents from tanneries, textile and paper Mills create local pockets of pollution in all the three rivers namely Kabul, Shah Alam and Naguman. Sufficient dilution and available oxygen is important in minimizing the impact of organic pollution. It is suggested that proper treatment plants may be installed to treat the industrial effluents prior to discharge into Kabul River which may reduce the organic pollution and presence of high number of *Fecal coliform*. After this treatment river water can be made fit for various uses including human consumption.

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