Surface water quality in and around Dhaka City
K. M. A. Sohel, M. A. I. Chowdhury and M. F. Ahmed

ABSTRACT

The quality of water, from both surface and groundwater sources, has recently being endangered by many factors, natural and man-made, which have caused a deterioration. The quality of the water sources used in Bangladesh is at high risk, especially in the capital city of Dhaka, due to increased pollution resulting from unlimited migration of rural people. Consequently, the existing groundwater-based water supply system is not adequate to fulfil the water demand of the mega-city Dhaka. To alleviate the city’s present severe water crisis, the question has been asked as to why the Dhaka Water Supply and Sewerage Authority (DWASA) is not using the rivers around Dhaka as a source of water. In this context, DWASA is seriously considering two options: (i) introduction of a separate water supply system for domestic purposes other than drinking water by pumping available river water around the city; and (ii) installation of a small-scale treatment plant for water supply using river water around the city as a source of raw water. Implementation of either of these options will require a study on the quality of the water sources, and development of appropriate cost-effective treatment methods. A study has been conducted at the Bangladesh University of Engineering and Technology (BUET) to evaluate the important physical, chemical, and biological water quality parameters of the five rivers around Dhaka City. Test results indicate that the water of all rivers around Dhaka City is highly polluted during the dry season, except for water of the River Sitalakhya. The important water quality parameters in the dry and wet seasons, when compared with earlier values, indicate that the degree of pollution of these rivers is gradually increasing with time. This paper focuses on the study and analysis of important water quality parameters of river waters around Dhaka City.

Key words | BOD$_5$, colour, faecal coliforms, river water, total solids, turbidity

INTRODUCTION

Water is one of the vital components of the physical environment. Because of the growing global awareness in the maintenance of a ‘clean world’, public and private agencies have come to realize the importance of surface water to a nation’s economy. Knowledge of water quality thus plays a significant role in the development of water quality control and management (Lohani & Todino 1984).

Bangladesh, the fifth most densely populated country of the world (PRB 1998), inhabited by 129 million people (BBS 2001), is largely dependent on surface water sources such as rivers, ponds, canals, ditches, etc., for domestic water supply, especially in rural areas. In comparison with groundwater abstracted by tube-wells, these surface water sources have often been more convenient, easily accessible and socio-economically preferable for the majority of the rural population for many domestic purposes. But the practices of indiscriminate defecation and disposal of raw sewage into these surface water bodies have created a heavily polluted environment which is of major concern because it has potential to serve as a reservoir or carrier of pathogens of water-related diseases (Bilqis et al. 1988).

Dhaka, the capital city of Bangladesh, is presently the 22nd largest mega-city in the world (Kazi 1999) with an area of about 260 km$^2$ and a population of nearly 10

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million, and is predicted to be the 9th mega-city in the world with about 20 million residents in the year 2015 (Sadik 1996) with a population growth rate of 6% per annum (Rahman & Islam 2000). The scarcity of safe water for domestic purposes is already being experienced by the city dwellers. The magnitude of the problem is acute during the extreme dry and hot season due to the fact that during this period the yield of the tube-wells decreases and conversely the demand for water increases. The present water requirement of Dhaka City is about 1800 MLD, while the production is only about 868 MLD, thus indicating a large gap between demand and production.

At present, only 4% of the city’s water comes from the River Buriganga, via only a surface water treatment plant, while the major portion (96%) is abstracted from groundwater sources through the installation of 234 deep tube-wells throughout the city. Although a large number of deep tube-wells are being sunk by DWASA in crash programs, the production is not increasing proportionately due to the rapid decline in the groundwater level; also there is no space within the densely populated area to sink more tube-wells without interference. Moreover the aquifer beneath the city is unable to produce more water in a sustainable manner.

Obviously, to meet the growing water demand, DWASA will have to depend largely on surface water resources from the rivers around Dhaka City. Five rivers, namely: Buriganga (Bu), Sitalakhya (Si), Balu (Ba), Turag (Tu) and Tongi (To), around Dhaka, could be potential sources of additional water for the city. But the quality of water in these rivers is likely to be poor because physical, chemical and biological contamination, resulting from human activities such as defecation, discharge of agro-chemical and industrial waste, etc., causes indiscriminate deterioration of the water quality. To ensure that the quality of the water to be supplied to the people of Dhaka City from the surrounding rivers will be adequate, the present study was undertaken as part of the post-graduate program of the Environmental Engineering Division of the Civil Engineering Department of Bangladesh University of Engineering and Technology (BUET), with the objective of evaluating the important physical, chemical, and biological water quality parameters, relevant to water supply, of the five rivers around Dhaka City.

**Figure 1** | River system around Dhaka City.

**WATER SOURCES CONSIDERED FOR EXAMINATION**

The rivers Turag, Balu and Tongi, which are hydraulically connected with the two big rivers Buriganga and Sitalakhya downstream, as shown in Figure 1, were all considered for the study.

**Buriganga River**

The water quality of the River Buriganga, which receives domestic, industrial, agricultural and other wastewater discharges, is deteriorating due to the increasing pressure of urbanization and industrialization in Dhaka City. A large number of tanneries (around 200) located in the Hazaribug and Rayer Bazar areas of Dhaka, use more than
200 chemicals, including several types of acid, preservative, lime, sodium chloride, chromium, etc. The Buriganga has been highly contaminated by the tanneries’ effluent. Tannery effluent contains BOD levels between 0.07 g/l and 0.35 g/l (JICA & DWASA 1998).

Sitalakhya River

The water quality of the tidal river Sitalakhya (shown in Figure 1) is deteriorating due to the untreated wastes discharged to the river from the industries situated in the Demra and Narayangang areas (JICA & DWASA 1998).

Balu River

The River Balu runs around the northeastern periphery of Dhaka City and collects water from the River Old Brahamaputra. It discharges into the River Sitalakhya near Demra. The Balu is also connected to the Tongi River. A large amount of domestic and industrial wastewater is discharged into the Balu. During the dry season, the sewage discharge is concentrated due to the reduction in natural flow of the river; accordingly the quality of the river water is considerably degraded. The largest pollutant source of the Balu is the combined discharge of the Paribagh and the Begun Bari Khals. These two khals are seriously polluted with industrial wastewater from the Tejgaon industrial area, as well as domestic sewage.

Tongi River

The River Tongi is situated along the southern boundary of the Tongi Pourashava. The dissolved oxygen (DO) profile for the dry period shows that along the entire reach of the Tongi River, the DO value is below critical levels. This is a strong indicator of deteriorating water quality due to the industrial wastewater being discharged from the Tongi industrial estate (JICA & DWASA 1998).

Turag River

The River Turag has a total length of 75 km and flows near the northwestern boundary of Dhaka City. It receives its water from the Bangalee and discharges into the Buriganga. The industries near Tongi, mainly textile, jute and tanneries, discharge their wastes into the Turag without treatment (JICA & DWASA 1998).

EXPERIMENTAL APPROACH TO WATER QUALITY ANALYSIS

Sample collection

Meaningful and reliable sampling assures the validity of analytical findings. The shorter the time interval between the collection of a sample and its analysis, the more reliable the results are. It is difficult to state exactly how much time was allowed between the collection of a sample and its analysis. The following maximum limits were followed as much as possible, as suggested in Standard Methods (APHA 1998) as being reasonable for physical and chemical analyses: unpolluted waters, 72 h; slightly polluted waters, 48 h; and polluted waters, 12 h.

Clean plastic bottles, having a capacity of 500 ml, were used for collection and preservation of water samples for physical and chemical examinations. Separate samples were collected for bacteriological examinations in sterilized bottles. The utmost care was exercised to ensure that the analyses were representative of the actual composition of the water sample. Prior to filling, the sampling bottle was rinsed out two to three times with the water to be collected. Collected samples were promptly carried to the laboratory and almost all the physical and chemical properties were then determined. All possible efforts were made to minimize the time lag between collection and analysis, so that no significant change in the quality of the river water could occur. From each of the sampling points, at least three raw samples were collected and analysed. The average of the three results was considered as the representative result.

Location of sampling points

Raw water samples were collected from ten locations along the five rivers around Dhaka City for routine
laboratory analysis at different seasons of the year. Three sampling points were near Kamragirchar, Chadnighat, and the China-Bangladesh Friendship Bridge along the Buriganga; along the Balu, one sampling point was near Norai Khal and other near Demra Bazar; there were two sampling points along the Sitalakhya, one near Demra (at the intake of the proposed Saidabad water treatment plant) and the other downstream of Katchpur bridge; on the river Tongi there was one sampling point near Tongi Bazar; and on the Turag there was one sampling point near Tongi Bazar (Uttara) and another upstream of Gabtali Bazar.

Parameters considered

Water samples collected from the rivers around Dhaka City were tested for physical, chemical and bacteriological parameters to determine the water quality and the degree of pollution. Physical parameters measured were total solids (both dissolved and suspended), turbidity, colour, temperature, taste and odour. Chemical analyses were performed for alkalinity, pH, total hardness, iron, Biochemical Oxygen Demand (BOD$_5$), nitrate, phosphate, permanganate value, zinc, lead and chromium. A bacteriological test was carried out only for faecal coliform colonies per 100 ml in the water sample.

Apparatus used for water quality measurements

The following pieces of equipment were used: a Hach digital turbidity meter, an electronic balance, a Nessler tube, a pH meter, a Hach programmable spectrophotometer, an atomic absorption spectrophotometer, a thermometer, a titration unit, an incubator, a suction filter, and a membrane filter.

RESULTS OF THE ANALYSIS OF RIVER WATER QUALITY AROUND DHAKA CITY

A routine laboratory analysis of water quality parameters was performed for physical, chemical and biological qualities according to Standard Methods (APHA 1998). A study of the potability of water from different rivers around Dhaka City was conducted at different times from February 1998 to October 1999. The test results of important water quality parameters, showing the seasonal fluctuation for different rivers, are presented below.

pH

The pH values of the river waters were determined by a digital pH meter. Figure 2 represents the variation in pH of the five rivers in both dry and wet seasons. The variations of pH at different seasons were very small. The variation in pH was found to be between 7.4 and 7.8 in the Sitalakhya, between 7.5 and 7.8 in the Balu, between 7.3 and 7.8 in the Tongi, and between 7.7 and 7.9 in the Turag. These results are similar to Islam’s (1977) investigations. He showed that in 1973–74, the pH value in the Buriganga was between 7.10 and 7.55 and in the Sitalakhya it was between 7.20 and 7.60. In the dry season (February), the pH value was higher in the Buriganga, Sitalakhya and Balu rivers. In the Tongi river the pH value was found to be lower in the
dry season than in the wet season (July). Acidic discharges from industrial areas in the dry season could be the reason for lower pH values in the Tongi river water.

**Alkalinity**

Alkalinity was determined by the acid titration method. Figure 3 shows the variation of total alkalinity in mg/l as calcium carbonate (CaCO₃) in water samples of the rivers. The total alkalinity of the Buriganga water in the dry season was on average 246 mg/l, and in the wet season it was 157 mg/l. The total alkalinity in Sitalakhya river water in the dry and wet seasons was on average 147 mg/l and 53 mg/l respectively. Similarly the total alkalinity in the dry and wet seasons was 199.5 mg/l and 59 mg/l respectively in the Balu, 172 mg/l and 59 mg/l in the Tongi, and 188 mg/l and 65 mg/l in the Turag. It appears from the test results that the total alkalinity of rivers around Dhaka City in both dry and wet seasons does not exceed the permissible limit of 400 mg/l for a water source. In 1973–74 the value of alkalinity in the Buriganga was between 148 and 175 mg/l and in the river Sitalakhya it was between 30 and 56 mg/l (Islam 1977), i.e. the alkalinity of the river waters is increasing slowly.

**Turbidity and colour**

Turbidity is expressed in neophromatic turbidity unit (NTU). The Buriganga river water was found to be highly turbid in the wet season but only slightly turbid in the dry season; the maximum and minimum turbidity was 87 NTU and 14 NTU respectively. The turbidity of the rivers around Dhaka City is given in Figure 4. The maximum and minimum turbidity values of river waters in different periods from February 1998 to October 1999 are given in Table 1.

The colour of the water samples was determined by a Hach programmable spectrophotometer at the wavelength of 455 nm. Colour is expressed in platinum-cobalt (Pt-Co) units. The colour value was found to be 128 units in the wet season and 131 units in the dry season in the Buriganga. The maximum colour value was 187 units in the Turag during the wet season. On average the Sitalakhya river water is less coloured than that of other rivers around Dhaka City. The concentration of colour present in river waters around Dhaka City is given in Figure 5. The maximum and minimum colour values of

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**Figure 3** | Total alkalinity of various river waters around Dhaka City.

**Figure 4** | Turbidity of various river waters around Dhaka City.
Table 1 | Maximum and minimum turbidity of river waters around Dhaka City

<table>
<thead>
<tr>
<th>Turbidity (NTU)</th>
<th>Buriganga</th>
<th>Sitalakhya</th>
<th>Balu</th>
<th>Tongi</th>
<th>Turag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum turbidity</td>
<td>87</td>
<td>169</td>
<td>156</td>
<td>108</td>
<td>118</td>
</tr>
<tr>
<td>Minimum turbidity</td>
<td>14</td>
<td>18</td>
<td>13</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 2 | Maximum and minimum colour of the river waters around Dhaka City

<table>
<thead>
<tr>
<th>Colour (Pt-Co units)</th>
<th>Buriganga</th>
<th>Sitalakhya</th>
<th>Balu</th>
<th>Tongi</th>
<th>Turag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum colour</td>
<td>292</td>
<td>225</td>
<td>225</td>
<td>110</td>
<td>310</td>
</tr>
<tr>
<td>Minimum colour</td>
<td>51</td>
<td>92</td>
<td>82</td>
<td>95</td>
<td>112</td>
</tr>
</tbody>
</table>

river waters in different periods from February 1998 to October 1999 are shown in Table 2.

In the dry season water contains more decomposable organic matter which produces colour, whereas in the absence of much silt and clay in the dry season the turbidity is mostly low. In the dry season the flow of water in the Balu, Tongi and Turag rivers was found to be practically absent. Since both colour and turbidity of the river waters are very high, extensive treatment will be required to improve water quality to an acceptable level.

Taste and odour

Many substances with which water comes into contact, either in nature or during use by humans, may impart perceptible taste and odour. These include minerals, metals, and salts from the soil, end products from biological reactions, constituents of wastewater, etc. Inorganic substances are more likely to produce tastes unaccompanied by odour. Alkaline materials impart a bitter taste to water, while metallic salts may give a salty or bitter taste. In the dry season, the Balu, Tongi and Turag rivers give off a rotten smell and have a bitter taste. Buriganga river water has a bitter taste and foul odour. Sitalakhya river water has no odour in the dry season. In the wet season, none of the rivers around Dhaka City have any objectionable taste or odour.

Solids content

Total solids, dissolved solids and suspended solids of river waters were determined by test procedures described in Standard Methods (APHA 1998). The concentrations of total solids (TS) in the Buriganga, Sitalakhya, Balu, Tongi, and Turag rivers were 347 mg/l, 244 mg/l, 237 mg/l, 398 mg/l and 380 mg/l respectively in the dry season. In the wet season the values were 364 mg/l, 326 mg/l,
304 mg/l, 238 mg/l and 297 mg/l respectively (as in Figure 6). Maximum and minimum TS values in the river waters in different periods from February 1998 to October 1999 are given in Table 3.

The concentrations of dissolved solids in the Buriganga, Sitalakhya, Balu, Tongi and Turag rivers were 220 mg/l, 173 mg/l, 206 mg/l, 302 mg/l and 319 mg/l respectively in the dry season and 197 mg/l, 169 mg/l, 194 mg/l, 95 mg/l and 125 mg/l in the wet season. The concentrations of suspended solids in the Buriganga, Sitalakhya, Balu, Tongi and Turag rivers were 127 mg/l, 172 mg/l, 31 mg/l, 96 mg/l and 62 mg/l respectively in the dry season and 167 mg/l, 157 mg/l, 110 mg/l, 43 mg/l and 174 mg/l in the wet season as shown in Figure 7. The higher value of the total solids contents in the wet season is due to the presence of large amounts of silt and clay particles in the river water. The acceptable levels of dissolved and suspended solids in drinking water are 1000 mg/l and 10 mg/l respectively (ECR 1997). Suspended solids in the waters of all the rivers exceed the Bangladesh drinking water quality standard. So for water supply, excess suspended solids should be removed.

**Total hardness**

The total hardness of water was determined through titration. The concentrations of total hardness in Buriganga, Sitalakhya, Balu, Tongi and Turag river waters in the dry season were 214 mg/l, 198 mg/l, 215 mg/l, 245 mg/l and 215 mg/l respectively. In the wet season these values were 53 mg/l, 48 mg/l, 48 mg/l, 50 mg/l and 50 mg/l respectively (as in Figure 8). Test results indicate that surface water around Dhaka City had higher total hardness values in the dry season, which is caused by the salts from industrial waste discharges. During the rainy season there is more water to dilute the discharges so there is a lower concentration of salts, thus producing lower total hardness values.

**Biochemical oxygen demand (BOD₅)**

The variation of BOD₅ in the waters of the rivers around Dhaka City is presented in Figure 9. The BOD₅ values in
Buriganga, Sitalakhya, Balu, Tongi and Turag rivers in the dry season were 28 mg/l, 12 mg/l, 62 mg/l, 42 mg/l and 35.5 mg/l respectively. In the wet season these values were 6.4 mg/l, 2.1 mg/l, 5.7 mg/l, 5.2 mg/l and 5.3 mg/l respectively. It shows that BOD5 in the dry season is higher than that in the wet season. In the dry season, the volume of water in the rivers is much reduced, which causes a higher concentration of organic matter than in the wet season. Islam (1977) observed that the BOD5 value was between 0.7 and 1.60 mg/l in the Buriganga river, 0.6 and 1.5 mg/l in the Sitalakhya river and 0.80 and 1.80 mg/l in the Balu river in 1973–74. Compared with the results presented here, it can be said that the river water quality around Dhaka City has deteriorated significantly since 1973–74.

Maximum and minimum BOD5 values of river water, in different periods from February 1998 to October 1999, are given in Table 4.

### Table 4 | Maximum and Minimum BOD5 values of river waters around Dhaka City

<table>
<thead>
<tr>
<th>BOD5 (mg/l)</th>
<th>River</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buriganga</td>
</tr>
<tr>
<td>Maximum BOD5</td>
<td>38</td>
</tr>
<tr>
<td>Minimum BOD5</td>
<td>6.1</td>
</tr>
</tbody>
</table>

**Nitrate and phosphate**

The nitrate concentration in all rivers around Dhaka City ranged from 0.12 mg/l to 1.35 mg/l. The maximum value in Tongi river water was found to be 1.35 mg/l in the dry season. In the wet season this range was 0.1 to 0.92 mg/l (as shown in Figure 10). Phosphate concentrations in the Buriganga, Sitalakhya, Balu, Tongi and Turag river waters in the dry season were 1.66 mg/l, 0.95 mg/l, 1.5 mg/l, 0.93 mg/l and 1.9 mg/l respectively. These values in the wet season were 0.88 mg/l, 0.075 mg/l, 0.22 mg/l, 0.22 mg/l and 0.20 mg/l respectively (see Figure 11).
Higher values of 1.75 mg/l in Buriganga river water in the dry season, and 1.9 mg/l in Turag river water in the wet season were found.

**Heavy metals (chromium, zinc and lead)**

Contamination of river water by chromium around Dhaka City results from industrial wastes (chrome-plating, textile, ceramic, glass, tannery industries etc.). Measurement of metals in water was made using an atomic absorption spectrophotometer. In the dry season, the chromium concentrations in the Buriganga, Sitalakhya, Balu, Tongi and Turag rivers were 0.018 mg/l, 0.0187 mg/l, 0.0365 mg/l, 0.06 mg/l and 0.1955 mg/l respectively, and 0.013 mg/l, 0.01 mg/l, 0.0001 mg/l, 0.001 mg/l and 0.05 mg/l respectively in the wet season as shown in Figure 12. The maximum chromium concentration of 0.13 mg/l was found in the River Turag near Gabtali Bazar (Amin Bazar) in the dry season, which may be caused by leaching of chromium salts from surrounding areas.

Concentrations of zinc in the Buriganga, Sitalakhya, Balu, Tongi and Turag river waters were 1.78 mg/l, 2.77 mg/l, 2.64 mg/l, 2.44 mg/l and 2.4 mg/l respectively in the dry season. These values in the wet season were 0.733 mg/l, 1.12 mg/l, 0.25 mg/l, 0.21 mg/l and 0.78 mg/l respectively (as shown in Figure 13). The highest value recorded was 3.00 mg/l in the River Sitalakhya. The Buriganga, Sitalakhya, Balu, Tongi and Turag river waters contained 0.033 mg/l, 0.033 mg/l, 0.024 mg/l, 0.09 mg/l and 0.04 mg/l lead in the dry season, and 0.01 mg/l, 0.01 mg/l, 0.001 mg/l, 0.001 mg/l and 0.001 mg/l lead in the wet season as shown in Figure 14. Concentrations of lead in river waters around Dhaka City were lower than the maximum permissible limit of 0.05 mg/l, except for the River Tongi.
Coliform colonies

All rivers around Dhaka are contaminated by human excrement. Faecal coliform concentrations in the Buriganga, Sitalakhya, Balu, Tongi and Turag rivers in the dry season were 100, 6, 51, 188 and $35 \times 1000/100$ ml respectively, and the values in the wet season were 11, 2, 9.5, 35 and $14 \times 1000/100$ ml respectively as shown in Figure 15. The Buriganga and the Tongi rivers were highly polluted by faecal coliforms in the dry season. In 1973–74 the faecal coliform concentrations were between 6 and 180 colonies per 100 ml sample in Buriganga river water (Islam 1977) i.e. faecal pollution has increased tremendously over the last 25 years. Maximum and minimum faecal coliform concentrations in the rivers, in different periods from February 1998 to October 1999, are given in Table 5.

DISCUSSION

Test results indicate that all rivers around Dhaka City are highly polluted during the dry season except the Sitalakhya. The important water quality parameters in both dry and wet seasons, when compared with previous works (Islam 1977), indicate that the degree of pollution of these rivers is gradually increasing with time. Islam (1977) found that the values for total solids, turbidity and colour of the Buriganga river were 297 mg/l, 53 NTU and 34 Pt-Co units respectively; whereas the average value of these parameters during the time of this study increased to 355 mg/l, 60 NTU and 130 Pt-Co units respectively. The other important parameters such as $\text{BOD}_5$, bacterial colonies, heavy metals and nutrients have also increased significantly. The water quality of the Tongi and the Turag rivers was equally deteriorating with time, like the Buriganga, during the dry season. The rate of degradation of water quality of the Sitalakhya river was found to be lower when compared with previous works (Islam 1977).

The trends of increasing $\text{BOD}_5$ of the Buriganga and Sitalakhya rivers, based on earlier studies (Ahmed 1976, 1988; Islam 1977), are shown in Figures 16 and 17. The rate of increase of $\text{BOD}_5$ during the last 10 years is alarming. As far as the surface waters are concerned, the major sources are the five rivers, Buriganga, Sitalakhya, Balu, Tongi and Turag; these river water sources around Dhaka City are highly contaminated due to indiscriminate discharge of sewage and industrial waste. The $\text{BOD}_5$ and faecal coliform counts are also very high as compared with treatment by conventional methods. The fluctuation of major water quality parameters has also caused difficulties in the operation of the existing treatment plant. Therefore
the surface water of Dhaka City cannot be directly used for domestic consumption unless the water undergoes physical and chemical treatment to make it absolutely suitable for the purpose. The water can be treated, but the cost of treatment may be comparatively higher.

DWASA has a plan to supply river water to consumers for domestic purposes other than drinking. The high concentration of faecal coliforms in all the rivers is likely to contaminate everything that comes into contact with the water. Supply of river water without treatment may turn out to be a disaster. Moreover, river water without adequate dissolved oxygen in the dry season may have bad odours that will be repellent to the consumers. Among the five major river water sources around Dhaka City, the Sitalakhya is by far the best source in respect of water quality. As the Buriganga runs very close to the City, it has high potential for large-scale water treatment works, and thereby has an advantage over the Sitalakhya in respect of distance. In the dry season the rivers Tongi, Balu and Turag are almost dry and the discharges are very low. The dissolved oxygen content in these river waters in the dry season is almost zero (JICA & DWASA 1998), and the chemical examinations indicate that these river waters are contaminated to such an extent that they cannot be treated economically to provide a water supply for the City in the dry season. This can be achieved only in the wet (rainy) season.

The improvement of the river water quality by treatment processes such as sedimentation, sedimentation with coagulation, and filtration after coagulation, has also been investigated. The effectiveness of the treatment methods was critically analysed and the degree of treatment

Table 5 | Maximum and minimum faecal coliform concentrations in river waters around Dhaka City

<table>
<thead>
<tr>
<th>Faecal coliforms (*1000/100 ml)</th>
<th>Buriganga</th>
<th>Sitalakhya</th>
<th>Balu</th>
<th>Tongi</th>
<th>Turag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum concentration</td>
<td>143</td>
<td>9.5</td>
<td>81</td>
<td>188</td>
<td>40</td>
</tr>
<tr>
<td>Minimum concentration</td>
<td>9</td>
<td>1.8</td>
<td>8</td>
<td>35</td>
<td>12</td>
</tr>
</tbody>
</table>

Figure 16 | The increase of BOD$_5$ with time in the Buriganga river.

Figure 17 | The increase of BOD$_5$ with time in the Sitalakhya river.
required to achieve Bangladesh drinking water quality standards was identified (Sohel 1999).

CONCLUDING REMARKS

The five potential surface water sources for Dhaka City water supply are the rivers Buriganga, Sitalakhya, Balu, Turag and Tongi. The river Tongi is highly polluted throughout the year and in the dry season flow is reduced to almost zero. The rivers are being increasingly polluted with the passage of time, and turbidity, BOD₅, and faecal coliform concentrations fluctuate widely between the wet and dry seasons. The Buriganga and Tongi rivers contain high concentrations of organic substances in the dry season and the waters become gray to dark in colour. Faecal pollution of the rivers Buriganga and Tongi was higher than that of other rivers around Dhaka City. The important water quality parameters such as turbidity, colour, BOD₅ and faecal coliform counts, greatly exceed the acceptable level of a good source for water supply. The concentrations of metals measured in the study were found to be within acceptable limits.

The Sitalakhya river, as a potential water source, has some advantages over the other rivers with respect to water quality, while the Buriganga river may be considered preferable to the Sitalakhya when distance is taken into account. The water from the rivers Balu and Turag can only be treated effectively to provide a water supply for Dhaka City during the wet season. Extensive treatment is required to make the water of all the rivers around Dhaka City suitable for public water supply in the dry season.

Based on the analysis of the quality of the river waters around Dhaka City, the following recommendations are made to improve water quality:

1. Protection of the rivers around Dhaka City from pollution is needed, not only for the purpose of water supply but also for an improved environment and quality of life. Presently there are laws, rules and regulations, but hardly any implementation of these laws and rules to control discharge of pollutants into the rivers. Industrial outlets, as well as municipal sewer outfalls, discharge highly polluted wastewater into the rivers. Strict regulatory measures should be taken into consideration to compel the polluters to treat their wastes before discharging into the rivers. In this context capacity building, and the proper application of effective treatment of the wastewater of each and every industry located in and around Dhaka City, should be ensured before discharging the industrial contaminants to the river.

2. This study, which took place during only two seasons (dry and wet), is definitely insufficient to assess the fluctuating patterns of physical, chemical, and bacteriological characteristics of water. Monthly or bi-monthly monitoring and testing of water quality of rivers around Dhaka City should be initiated before taking decisions about the extensive use of river water to meet the increasing water demand of Dhaka City. A relevant comprehensive strategy for source protection should be made and implemented by DWASA before using surface water. Decisions about the extensive use of surface water should be based on observed improvements of water quality after implementing the protection of sources.

3. There are numerous contaminants which include poisonous chemicals such as arsenic, cyanide, barium, selenium, cadmium, silver, detergents, copper, chloroform extract, phenols, oil and grease, in addition to disease-causing bacteria such as streptococci, bacillus etc. The loads of these contaminants in the waters of these rivers should be investigated through a comprehensive study before large-scale use of these waters for water supply.

REFERENCES


K. M. A. Sohel et al. | Surface water quality in Dhaka

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