Variations in Water Quality of Danube River at Budapest City

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Abstract: The most important problems affecting the health of the Danube River ecosystems and the water users in the basin are the high nutrients loads (N and P), changes in river flow patterns and sediment transport regimes, contamination with hazardous substances including oils, competition for available water, microbiological contamination, and contamination with oxygen depleting substances. Our objectives were to investigate physical, chemical, biological and bacteriological status for water quality of the Danube River in Budapest city. Surface water temperature, electroconductivity, pH, dissolved oxygen content, biological oxygen demond (BOD_5),chemical oxygen demond (COD), cation ions (NH_4^+, K^+, Na^+, Ca^{2+} and Mg^{2+}), anion ions (Cl^-, NO_3^-, NO_2^-, SO_4^{2-} and PO_4^{3-}), total N and P contents, some heavy metal ions (Cu, Cd, Zn and Ni), total Fe and Mn, suspended materials, total dissolved organic carbon concentrations, chlorophyll-a content, total counts of aerobe heterotroph mesophile bacteria, total coliforms, faecal coliforms, faecal streptococci, Escherichia coli, Enterococcus faecalis and cellulose-decomposers were carried out during June of 1998, 2005 and 2010. According to the studied parameters and the Hungarian assessment methods, our results demonstrated that dissolved organic carbon content, nutrient pollution, bacteriological parameters and chlorophyll-a content were higher in 2005 than in 1998 and 2010. With large numbers of new chemical substances introduced to river ecosystem, continuous monitoring systems for their detection will become increasingly important with respect to environmental impacts they produce, in addition to other toxic effects. Thus the challenges to continuous physical, chemical, biological and bacteriological monitoring will be immense. Finally the importance of the integration of biological and physicochemical monitoring has to be emphasized.

Keywords: Environmental monitoring, pollution, Danube River water quality, ecological parameters

1   Intoduction

The hydrologic cycle is a very important and practical concept for maintaining a healthy and fundamental aspects life on the Earth. Water makes up a substantial part of living organisms, and those organisms need water for life. Therefore, managing water resources by thoroughly understanding the hydrologic cycle at scales ranging from the entire Earth to the smallest of watersheds is one of the greatest responsibilities of humans. Because fresh surface water and fresh groundwater are the only parts of the hydrologic cycle that can be used by humans, most interest in the hydrologic cycle by water managers is focused on these resources. Indeed, most researches in the hydrological sciences is devoted to understanding movement of water, and the movement of chemicals and sediment transported by water in watersheds. To assure adequate water resources for human use, water managers need to be able to measure the amounts of water that enter, pass through, and leave watersheds. This is a challenge because the relative magnitudes of the individual transfers in the hydrological cycle can vary substantially.

Anthropogenic activities associated with urbanization, industrialization and agriculture have led to the deterioration in water quality due to various contaminants. Rivers are dynamic ecosystems, and the problems of water quality such as pollution, toxicity development, eutrophication, dysfunction, acidification, etc are lowering the standard level of water.
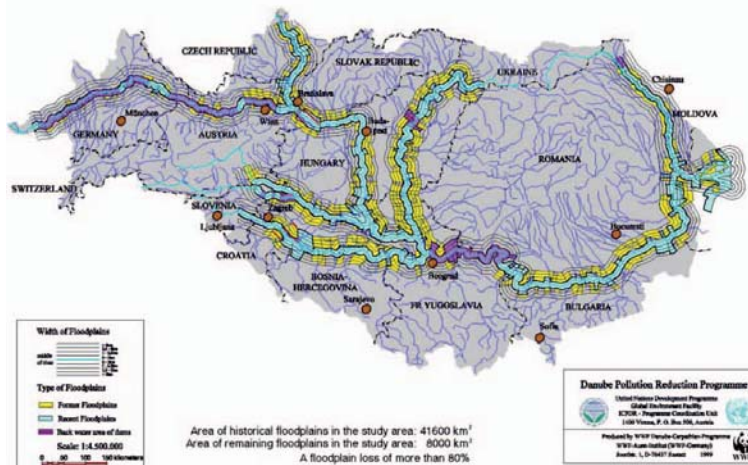

Plate 1

The pathway of Danube River

Water quality monitoring of international rivers has always been a difficult task. The major problem today is to improve the water quality of the river ecosystem to meet the demand from different sectors and to improve the capacity of water

supply for domestic, agriculture, industry, energy and other uses. The quality of human life is strongly related to a clean environment. The Danube River (Plate 1) is the second longest river in Europe with a length of about 2.800 km and the only major European river flowing from West (from Black Forest Mountains of Germany) to East (to Black Sea) of Europe and it flows through nine countries (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Ukraine, and Romania). One of the main problems that affect water quality of Danube River are high load of nutrients (N and P content) leading to eutrophication, contamination with hazardous substances and O_2 depletion.

After more than four decades of development there are a number of reliable chemical monitoring systems for river monitoring, but biological monitoring is still in the stages of infancy [1]. Chemical monitoring was introduced in most of the large rivers of Europe during the last four decades, with varying amount of sophistication.

Monitoring of the biological quality of rivers has a long tradition in the Danube River Basin. Several countries supported the researches on bioassessment and monitoring [2].

Most of natural waters contain dissolved ions derived from the water's interaction with soil, bedrock, atmosphere, and biosphere. The polar nature of the water molecule and the hydrogen bonds are responsible for many of water's unique physical and chemical properties. The chemical and physical properties of water depend on the amount and composition of dissolved materials. The electrical conductivity of water depends on the concentration and charge of the dissolved ions. Because of this relationship, conductivity often is used as an indicator of the total dissolved solids in the water, however, because a given value of conductivity can be produced by several different combinations of ion concentration and charge. One important chemical property of natural water that affects its ability to dissolve minerals and influence chemical reactions is its pH. The pH, which indicates the acidity of water, measures the abundance of positively charged hydrogen ions (H^+). Natural waters also can be neutral, but more often are either slightly acidic or slightly basic. Rain in unpolluted areas has a pH of about 5.6 due to the dissolution of CO_2 in the atmosphere. This slightly acidic nature enhances rain-water's dissolving power. These reactions result in the rainwater gaining dissolved calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), and other elements. In the natural environment, iron (Fe) can exist either as reduced iron (Fe^{2+}) or oxidized iron (Fe^{3+}). Iron is more soluble in the reduced state than it is in the oxidized state, where it often occurs as an iron oxide mineral (Fe_2O_3). Therefore, if the local environment produces the reduced iron form, the water will have higher concentrations of dissolved iron. The most common causes of a reducing environment are oxidation reactions involving organic matter. The oxidation of an organic molecule can result in iron, existing as a solid iron oxide mineral (Fe_2O_3), being dissolved into the water as reduced iron (Fe^{2+}). Other elements that behave similarly include manganese (Mn), sulfur (S) and nitrogen

(N). The purpose of the monitoring effort was to monitor changes in water quality resulting from changes in environmental changing practices.

Microbiological contamination is an important water quality problem in the World. The discharge of organic matter is considered to be a crucial problem throughout the Danube River basin have negative impacts on hydrobiology of Danube River and makes the water unhealthy for use. Kei et al. [3] investigated the relationship between concentrations of indicator bacteria and a chemical indicator in tropical and temperate regions. In Tokyo, higher bacterial densities were usually observed during summer. The results suggested that *E. coli* is a specific indicator of faecal contamination in both tropical and temperate regions but that the densities are affected by elevated water temperature and input from runoff of soil particles. The concurrent determination of *E. coli* concentrations could provide a possible approach to assessing the reliability of faecal pollution monitoring data. The main aim of our following environmental monitoring of Danube River is to draw an attention on the changing picture of water quality of the River in Budapest city during different time intervals (1998, 2005 and 2010).

2   Materials and Method

The investigated monitoring parameters of Danube River were classified as: physical (e.g., temperature, etc.), chemical (e.g., dissolved oxygen and pH, nitrate and phosphate levels: to monitor the nutrients, etc.); biological (turbidity and chlorophyll content to monitor changes in algae growth); and bacteriological status. Water sampling was performed by standard methods to estimate the water quality of the Danube River. The water samples of Buda and Pest sides of Danube River in Budapest city were collected during June of 1998, 2005 and 2010 from six sites of three different zones between Erzsébet and Petőfi bridges in Buda and pest sides. All samples for physical, chemicals, biological and bacteriological investigations were collected in (~1 litre) sterile dark bottles, immediately placed on dark cooling boxes, and processed within 6 h of collection. Environmental monitoring of Danube River water quality in Budapest sites were carried out according to the standard Hungarian methods. The following parameters investigated in this studies were: pH: MSZ 448-22-1985, temperature: MSZ EN 27888:1998, electroconductivity: MSZ 448-32-1977, NH_4^+: MSZ ISO 7150-1:1992, Na^+, K^+: MSZ 448-10-1977, Ca^{2+} and Mg^{2+}: MSZ 448-3-1985, Cl^-: MSZ EN ISO 10304-1:1998, NO_3^-: MSZ 448-12-1982, NO_2^-: MSZ 448-12-1982, PO_4^{3-}: MSZ 448-18-1977, CO_3^{2-}: MSZ 448-21-1986, SO_4^{2-}: MSZ 12750- 16:1988, total P: MSZ 448-18-1977, total N: MSZ 448-27-1985, total organic carbon content: MSZ EN 1484:1998, suspended materials: MSZ EN ISO 7827: 1998, dissolved O_2: MSZ EN 25814:1998, COD: MSZ ISO 6060:1991, BOD: MSZ EN 1899-1:2000, Fe: MSZ 12750- 34:1986, Mn: MSZ 1484- 2:1993, Ni, Cu, Zn and Pb: MSZ EN ISO 5961:1998.

Concerning the chlorophyll-a concentration and bacteriological properties the following methods were applied. Chlorophyll-a content: MSZ ISO 10260:1993, coliform: MSZ 12749:1993, total coliform: MSZ 12749:1993, *E. coli*: MSZ 448-44:1990 and *Enterococcus*: MSZ 12749:1993. Total aerobic mesophile heterotrophic bacteria were enumerated by standard plate count by serial dilution of the sample, followed by the conventional spread plate method [4]. The populations of bacteria were expressed in terms of $\log_{10}$. Cellulose decomposers were determined according to Hendricks et al. [5].

3   Results

To assess the status of Danube River water quality, water samples were collected from the main source from different localities of Budapest City in 1998, 2005 and 2010 for estimation of different environmental monitoring as mentioned above. Monitoring impacts of physical, chemical, biological and bacteriological factors on Dunabe River water quality in Budapest city are demonitrated in the following 11 figures. These results are presented in the avarege of 3 replicates of 6 investigated locations on both sides of the river. Figure 1 represents data of the pH and electroconductivity of Danube River water.

The pH values of water samples showed more alkaline in 2005 than in 1998 and 2010, while the eclectroconductivities measurements were at maximum in 2005 followed by 2010 and 1998. Also, Figure 1. shows significant differences between the pH values of 1998 and 2005 with 2010, but no significant difference between the pH values in 1998 and 2005. The results showed no significant differences between the electroconductivities in 1998 and 2010, but it was significant between 1998 and 2005 as well as between 2005 and 2010.
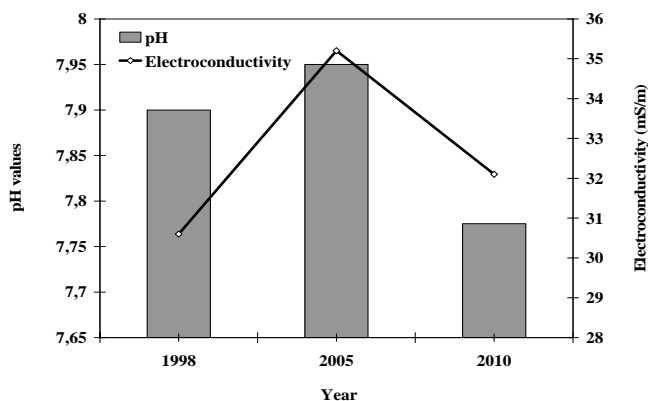
Figure 1

Measurements of pH and electroconductivity in Danube River in Budapest city

Figure 2 represents the comparative monitoring measurements of temperature and dissolved O_2. No significant differences were found between the temperature degrees in 1998 and 2005 but, it was significant with the data in 2010, as well as between the recorded data in 2005 and 2010.
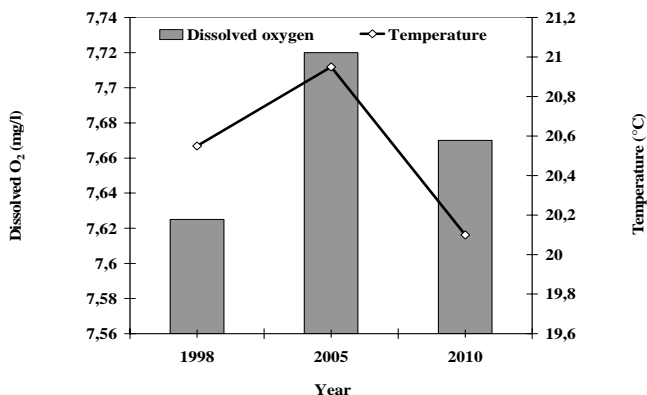

Figure 2

Dissolved oxygen and temperature measurements in Danube River in Budapest city

The temperatures of water samples were highest in 2005 and lowest in 2010. The lowest dissolved O_2 measurements were recorded in 1998, while in 2005 were the highest values in comparison with in 2010. Maximum Ca^{2+} ion concentrations were measured in 2010. Also, Mg^{2+}, Na^+, K^+ and NH_4^+ ion concentrations were highest in 1998 and the lowest concentrations were in 2010 (Figure 3).
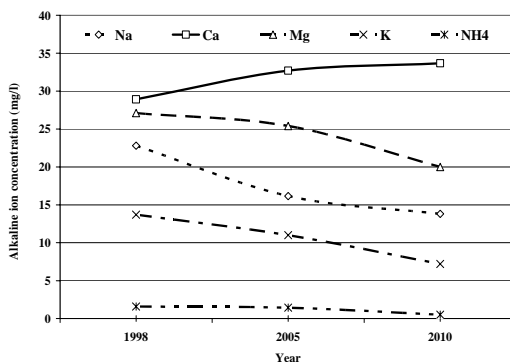

Figure 3

Values of alkaline ions concentration in Danube River in Budapest city

Generally, the ion concentration decreasing order was $Ca^{2+} > Mg^{2+} > Na^+ > K^+$ and NH_4^+. In Figure 4, results showed the anion ions concentrations in the

investigated water samples. Carbonate ion concentrations were found to be the domenant and highest anion level throughout all analyzed water samples in 1998, 2005 and 2010.
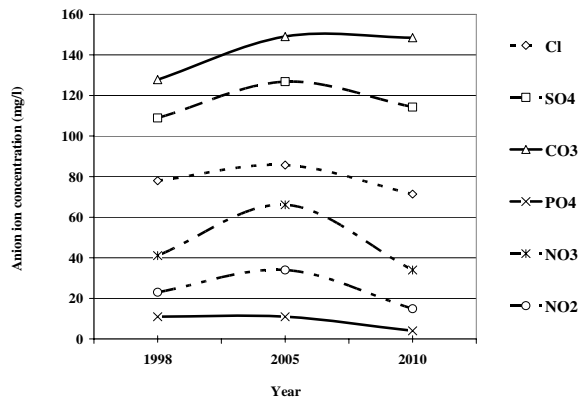

Figure 4

Different anion ions concentrations in Danube River in Budapest city

Carbonate ion concentrations were at lowest in 1998 and more higher in 2010 than in 2005. Sulphate was followed the canbonate in the anion ion concentrations and followed by chloride, nitrate, nitrite, and followed by the phosphate which showed the lowest anion ion concentrations. Nitrite, nitrate and chloride ion concentrations were at lowest in 2010 and at maximum in 2005. Sulphate ion concentrations were at lowest in 1998.

Figure 5. illustrates the total N and P contents in the tested water samples. It was found that the highest values of total N and P were in 2005. The results showed that the total N contents were highly reduced in 2010, also, there was no differences between the values of P contents in 2005 and 2010.
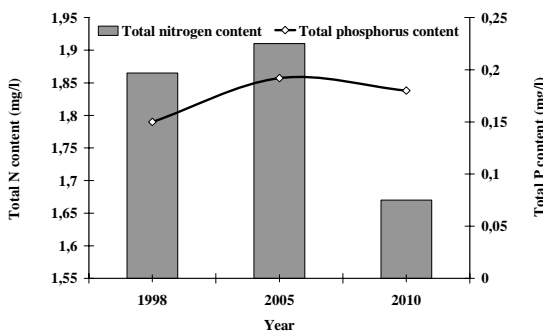

Figure 5

Measurements of total nitrogen and phosphorus contents in Danube River in Budapest city

Figure 6 demonstrates the ion concentrations of Mn and Fe. The lowest concentrations were recorded in 2010. Maximum Mn ion concentrations were measured in 1998 and for Fe was in 2005.
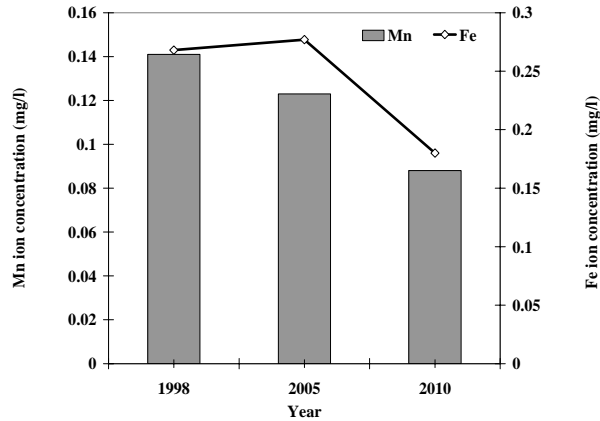

Figure 6

Ion concentrations of manganese and iron in Danube River in Budapest city

The lowest ion concentrations of Zn, Cu, Cd and Ni were measured in 2010 (Figure 7), while in 1998 maximum comcentrations were recorded. Among heavy metals, the highest ion concentrations were recorded by Zn followed by Cu, Ni and Cd.
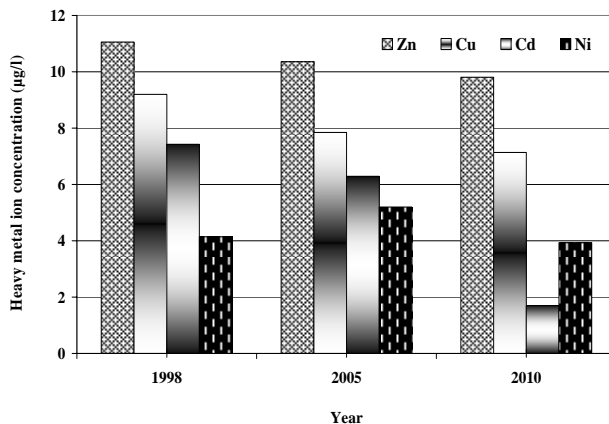

Figure 7

Concentrations of some heavy metal ions in Danube River in Budapest city

The BOD and COD were not show significant differences among the recorded data in 1998, 2005 and 2010. Maximum values were measured in 2005. The lowest values of BOD were recorded in 1998 and for COD were in 2010 (Figure 8).

Figure 8

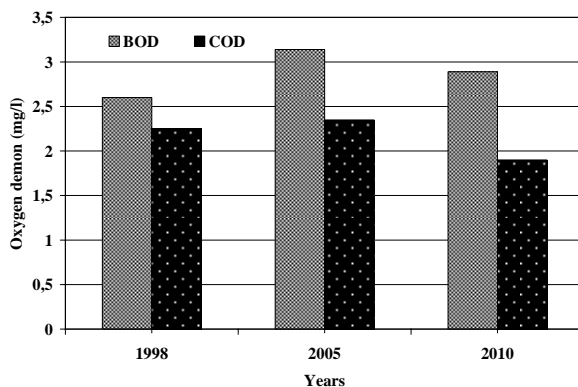Biological and chemical oxygen demand in Danube River in Budapest city

Figure 9 shows the concentration values of suspended materials and total organic carbon. It was found that the amounts of suspended materials and total organic carbon were lower in 1998 than 2005 and more than those measured in 2010.
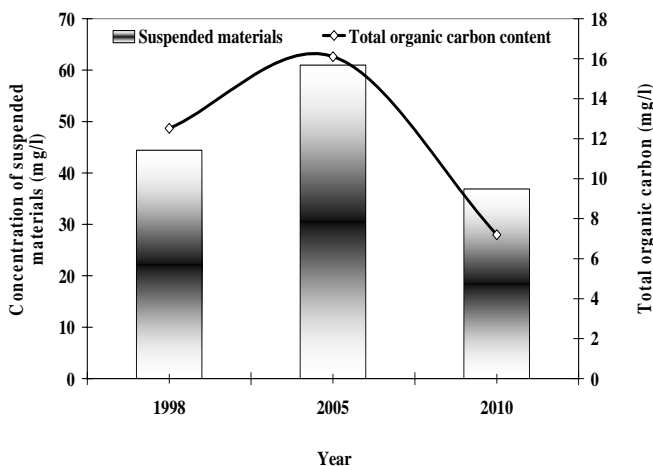

Figure 9

Concentrations of suspended materials and total organic carbon in Danube River in Budapest city

The data illustrated positive correlations between the amounts of suspended materials and total organic carbon throughout the investigated intervals. Chlorophyll-a concentration of planktonic organisms acts as an indicator for eutrophication. Figure 10 shows one of the biological indicators is the contents of chloropyll a in Danube River water quality. The monitoring method showed that the chlorophyll a was lowered in 2010 than 2005 and higher than the measurements in 1998. Microbiological contamination by pathogens is an important water quality problem in the Danube River section. Systematic and comprehensive data for microbiological parameters in the water sources of the basin are not available.

Our results showed that the enumeration of total counts of aerobe heterotroph mesophile bacteria, coliforms, faecal coliforms, faecal streptococci, Escherichia coli, Enterococcus faecalis and cellulose-decomposers of water samples collected from the Danube River are illustrated in Figure 11. The bacteriological assessments showed that the total counts of aerobic heterotroph mesophile bacteria and the total cellulose-decomposers were gradually increased from 1998 to 2010 (Figure 11).
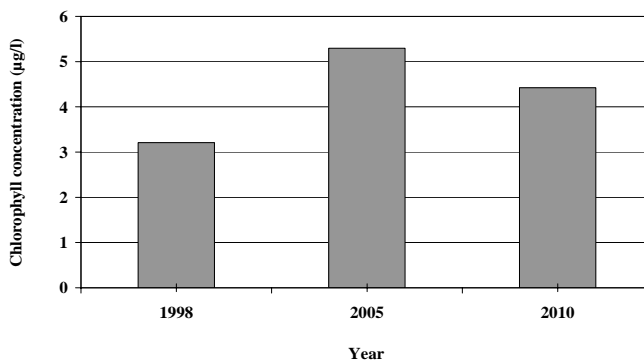

Figure 10

Concentration of chlorophyll a in Danube River in Budapest city

One-way analysis of variance demonstrated significant differences in total counts of aerobe heterotroph mesophile bacteria, coliforms, faecal coliforms, faecal streptococci, *E. coli*, *Enterococcus* faecalis and cellulose-decomposers densities between the surveys at $P < 0.05$. The highest log10 of *E. coli* per 100 ml was found during 2005 season (2.04), followed by the 2010 (1.47) season and 1998 (1.37) in Budapest. Meanwhile, *E. coli* numbers were found to decrease by the approximately similar order of magnitude in 2010 like 1998. The results showed approximately similar order of magnitudes of total counts of aerobe heterotroph mesophile bacteria, coliforms, faecal coliforms, faecal streptococci, Enterococcus faecalis and cellulose-decomposers densities to *E. coli* during the investigation

intervals in 2010 like 1998 were found. The measured bacteriological indicator parameters provided a consistent picture of faecal pollution in the Danube River in Budapest city throughout the three investigation years. In the third measurement in 2010, a dramatic increase of faecal indicators level at the capital of Hungary occurred was higher than the levels measured in 1998 and lower than as found in 2005 levels.
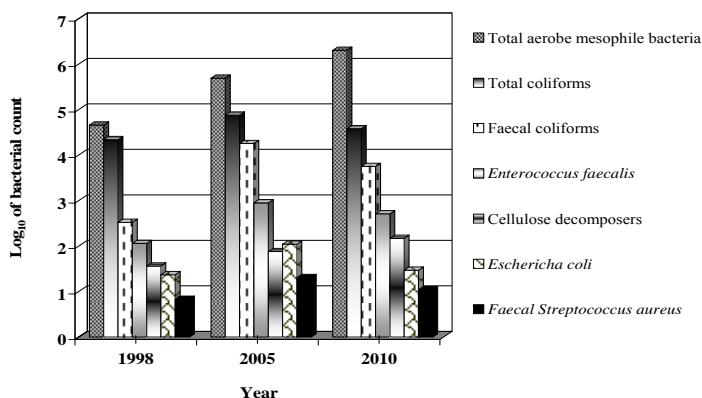

Figure 11

Bacteriological properties in Danube River in Budapest city

Highest enterococci concentrations were also observed in 2005, followed by 2010 and 1998. Total coliforms also showed by highest contamination levels in 2005 and the difference between the contamination in 1998 and 2010 is very low. Faecal indicators were all highly significantly intercorrelated in three years. The ratio between *E. coli* and enterococci varied from 0.545 (1998), 0.692 (2005) to 0.543 (2010). Significant difference was observed among bacteriological indicators in the Danube River within the sampling intervals. The comparison of data between the three years showed a high correlation for all investigated faecal pollution parameters despite the fact that different parameters were measured between 2010 and 1998. A high correlation was observed near to the 1:1 line (between 1998 and 2010). All faecal pollution parameters showed a consistent correlation pattern with the concomitantly measured environmental variables. significant correlation was found with chlorophyll a, bacterial production, particulate dissolved organic C content and suspended materials. All other variables (water temperature, pH, NO_3, NH_4, total N, P, electroconductivity, suspended materials and DOC) showed no significant correlation with faecal indicators. Bacterial numbers positively correlated with enterococci and total coliforms, which were as well negatively correlated with PO_4. Significant correlations of faecal indicators were observed for the whole data set including chlorophyll a, total P and total suspended materials.

A high ratio of *E. coli* to faecal streptococci suggests a human source and a ratio less than one suggests an animal source. A differential count of the actual streptococcal species present in water can help to find out the exact source of contamination.

4   Discussion

Wastes from cities and industries, chemical fertilisers, and manure from intensive and large-scale livestock operations are polluting the river system and the groundwater, raising nutrient levels and causing eutrophication. Other highly polluting activities include petrochemicals processing, iron and metal processing, timber, paper and pulp, and municipal solid waste disposal. Microbiological contamination is a problem throughout the river basin; it is generally caused by the discharge of urban waste and storm waters, as well as by livestock and agricultural run-off. The countries of the Danube River basin and interested governments and international institutions met in Sofia, in September 1991, to draw up an initiative to support and reinforce national actions for the restoration and protection of the Danube River - the Environmental Programme for the Danube River Basin (known as the Danube Environmental Programme: DEP). The DEP supports monitoring, data collection and assessment, emergency response systems, and preinvestment activities in the basin. Most of cities located on the banks of the river use raw water from the river for drinking water supply and discharge the untreated/treated municipal sewage into it. Water acts as a media for both chemical and biochemical reactions and also as internal and external medium for several organisms. Rapid population growth and urbanization have been accompanied by high health risks due to increasing inputs of untreated domestic wastewater to rivers. Water quality is one of the main issues in the water sector in all over the World and its improvement is a major concern. There is strong and direct link between people's health and improvement and the development of communities [6]. A critical evaluation of data presented indicated that pH generally ranged from 7.02–7.30; turbidity varied from 0.34–2.79 NTU; conductivity fluctuated from 359–374 μS cm^{-1}; and TDS values were found to be ranging between 180–187 mgl^{-1}. To ascertain the quality of drinking water being supplied, water quality monitoring and surveillance was conducted in Gangtok city at various treatment stages, service reservoirs, distribution network, public standposts, and households. No significant change in raw water quality was observed on day-to-day basis. Residual chlorine was found in the range of nil to 0.2 mg^{-1} in the sump water/finished water. Throughout the year (i.e., during summer, winter, and monsoon seasons), the total coliform and fecal coliform counts were ranged from nil to 7 CFU 100 ml^{-1} and nil to 3 CFU 100 ml^{-1}, respectively, in sump water of Selep and VIP complex water treatment plant; however, at consumer end, those were observed as nil to 210 CFU 100 ml^{-1} and nil

to 90 CFU 100 ml^{-1}, respectively. These variations in bacterial counts among the different service reservoirs and consumer ends may be attributed to the general management practices for maintenance of service reservoirs and the possibility of enroute contamination. Evaluation of the raw water quality indicates that the water is suitable for drinking after conventional treatment followed by disinfection. The finished water quality meets the level of standards described as per Bureau of Indian Standard specifications for potability in terms of its physicochemical characteristics [7].

Ahmad and Qadir [8] mentioned that the physicochemical parameters such as pH, electrical conductivity (EC), total dissolved salts (TDS), TH, HCO_3, NO_3, SO_4, PO_4, Na, K, Ca, Mg, Fe, F, and Pb have been analyzed. The results showed that values of the tested parameters for EC, TDS, TH, HCO_3, SO_4, and Na near the sugar mill were very high, which indicate the descent of standard norms of quality and protection procedures for the groundwater around this area. Srinivasamoorthy et al. [9] found that the water is neutral to alkaline in nature with pH ranging from 6.6 to 8.6 with an average of 8.0. Higher electrical conductivity was observed during post-monsoon season. The abundance of major ions in the groundwater was in the order of Na > Ca > Mg > K = Cl > HCO_3 > SO_4 > NO_3. Abdul Jameel and Sirajudeen [10] evaluated the current status of physicochemical contaminants and their sources in groundwater. The physicochemical parameters such as pH, EC TDS, TH, NO_3, SO_4, PO_4, Na, K, Ca, Mg, DO, BOD and COD have been analyzed.

Misra and Mishra [11] established the electrical conductivity of 50 samples each from dug wells, hand pumps and tube wells was analyzed for the study of salinity levels in shallow, intermediate and deep aquifers. Out of 50 samples, 20 samples of each were also analyzed for other chemical constituents such as Na^+, K^+, Cl^-, F^- and TDS. The analyses show drastic changes in the salinity levels of shallow, intermediate and deep aquifers. Moreover, there is an indication that the salinity and concentration of the above chemical constituents also escalate with time in each aquifer. The chemical constituents such as Na^+, K^+, Cl^-, F^- and TDS range from 51 to 165 mg^{-1}, 1 to 14 mg^{-1}, 224 to 1,459 mg^{-1}, 0 to 1.5 mg^{-1} and 750 to 2,650 mg^{-1}, respectively. Over a 3-year period, the salinity levels have sharply increased and the average F level has increased by 0.1-0.3 mg^{-1}. An attempt has been made here to discuss the factors causing the variation and escalation of chemical constituents and salinity in the water of the three aquifers.

Several studies have reported that the growth and survival of fecal indicator bacteria are sensitive to environmental factors, such as water temperature [12], sunlight [13], and rainfall [14]. Therefore, a more reliable indicator of water pollution than fecal bacterial enumeration needs to be developed. The rapid and simple enumeration of fecal bacteria, such as coliforms and fecal streptococci, is beneficial in fecal pollution monitoring in geographically large areas, and thus several water quality guidelines based on bacterial indicator densities have been established. However, the use of these indicators is controversial, especially in

tropical regions characterized by high temperatures and frequent rainstorms that facilitate erosion of soils. Kei et al. [3] mentioned that a reliable assessment of microbial indicators of fecal pollution (total coliform, *E. coli*, and fecal streptococcus) is critical in tropical environments. Sládeček [2] gave various examples of the direct relationship between biological oxygen demand (BOD) and the benthic invertebrate community. The author allocated a BOD of 2.5 mgl^{-1} to the lower range of oligosaprobic status, while the β-mesosaprobic status was characterised by BOD values of about 5.0 mgl^{-1}. Our results showed that the BOD values were laied between 2.5 and 3.5 mgl^{-1}. The abiotic screening criteria are either factors that affect the stream biota directly (P concentrations for diatoms; BOD, hydromorphology for invertebrates), or indirect, integrative indicators of various human influences (electroconductivity, land use).

Microbiological contamination from faecal pollution by anthropogenic sources is considered to be a crucial problem throughout the Danube River basin imposing a threat to all kinds of water uses [15]. Thus, detailed knowledge on the extent and origin of microbial faecal pollution is crucial for watershed management activities in order to maintain safe water use according to the quality targets. Here, our investigations suggested that the Danube River water quality was highly contaminated in 2010 more than in 2005 due to the sewage effluents.

Escherichia coli and intestinal enterococci are used worldwide as indicators for the assessment of faecal pollution in the aquatic environment. In fresh water, *E. coli* was shown to be a consistent predictor of gastrointestinal illness [16]. The use of total coliforms as indicators of faecal pollution in surface waters in international regulations has been abandoned in recent years because of the discovery that certain species belonging to this group are not of faecal origin [17]. Attempts to comprehensively monitor bacteriological quality in large, international rivers have been tackled by a number of organisations in Europe. For the Danube River, the only large-scale bacteriological investigation published to date deals with the changes of bacterial community composition along the whole river [18].

Our recorded data are full agreement with the combination of the faecal indicator data sets of the two Danube River surveys (JDS 2001, 2007) with major environmental parameters and the integration of long term observations at 16 representative sampling stations enabled us to draw for the first time a clear picture of the faecal pollution patterns along the longitudinal profile of this important international river. The COD data in Figure 8 are presented for comparative reasons. It can be depicted that the largest portions of wastewater directly entering the Danube River. However, from the observed microbiological pollution pattern in this study it can be assumed that a large portion also comes from sewage effluent. Available information on nutrient input along the Danube River shows that approximately 65% of all nitrogen and 43% of all phosphorus are entering the Danube River from non-point sources [19]. For phosphorus compounds, only a significant negative correlation with orthophosphate was observed for the Danube River. In contrast, significant positive correlations for all

faecal indicators were found with bacterial production for the Danube River while a positive correlation with chlorophyll a. The input of untreated sewage into the Danube River obviously leads to a concomitant increase in faecal indicators and nutrients enhancing the growthof autotrophic algae.

Inorganic nutrients are depleted by massive algal growth which in turn enhances secondary production like bacteria taking up exuded dissolved organic matter and zooplankton feeding on both phytoplankton and bacterioplankton. Due to this nutrient depletion, faecal indicators were not or even negatively correlated with inorganic nutrients, as it was the case for orthophosphate. Although, faecal indicators were highly significantly correlated with bacterial production. The highest chlorophyll a and organic N levels were only little faecal polluted indicating that other sources than municipal wastewater, most probably diffuse nutrient entered the Danube River. Cheshmedjiev et al. [20] mentioned that the assessment of water body for rivers is difficult to be summarized statistically because of the extremely large differences in size, both in geographic relation and in relation with relative water quantities. Concentrations of Cd, Cu, Pb, and Zn in river water were found to be highest in close proximity to locations of Cu and Pb–Zn mining regions in the Maritsa catchment. Downstream dispersal of solute metals in these catchments, and into the Danube River, was found to be limited by physical dilution and a well-buffered pH environment [21]. Vadadi-Fülöp et al. [22] reviewed the ecology of the Ráckeve-Soroksár Danube. Authors comprised the main studies beginning with the earliest faunistic publications up to the recent ecological, multidisciplinary investigations. Spatial and temporal patterns likewise water quality are considered as important. Additionally checklist of aquatic invertebrate and vertebrate fauna are given based on data from literature. Takács et al. [23, 24] mentioned that according to the investigated environmental parameters, our results demonstrates that the water quality of the main Danube River has become unstable during the last 12 years subsequent to the diversion which could be witnessed particularly in the unfavorable O_2 saturation levels. Our results indicate that additional protection monitoring investigations of the Danube River should be established.

Conclusions

On the basis of the results obtained in this study it can be concluded that the improvement of water quality of the investigated locations of Danube River in Budapest city is mainly depending on the many ecological factors and the quality and quantity of the available impurities carried out by the river from the source. Aso, it depend on the new chemical substances or impurities entering river systems, continuous monitoring systems for their detection will become increasingly important with respect to ecological impacts they produce. Much effort has to be directed towards the detection of such pollutants in rivers. Thus the challenges to continuous physical, chemical, biological and bacteriological monitoring will be immense. Finally the importance of integration of physical, chemical, biological and bacteriological monitoring has to be emphasized.

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