Biological Rapid Field Assessment of Water Quality in the Bagmati River and Its Tributaries, Kathmandu Valley, Nepal

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Abstract

Methods used in the biological assessment of the water quality of running waters in Nepal are described. The Bagmati River system and its tributaries in the Kathmandu Valley were investigated during the month of December 1995 and then mapped using methods which included the saprobic system and Nepalese Biotic Score (NEPBIOS) applied in combination with a detailed site report.

Introduction

The Bagmati is the main river in the valley of Kathmandu, the capital city of Nepal. In contrast to the various large snowfed rivers of the Himalayas, it is a small river originating from Bagdwar on Shivpuri Hill at an altitude of 2,650m (Mechi Dekhi Mahakali 1975). Running down rocky mountains, it descends to the plains of Nepal and ends in India by joining the Ganges. The total water course length from its origin to the border with India is 190km, covering a catchment area of 3,610sq.km., which is 2.25 per cent of the total area of Nepal.

There are 24 tributaries originating in the Mahabharat and Siwalik ranges which feed the Bagmati River. The exact site location of the river at Gokarna is 27°44'10"N latitude and 85°23'20"E longitude, and the falls at Chobhar span 27°39'40"N latitude and 85°17'40" and 85°17'50"E longitude.

Table 1: Major Tributaries of the Bagmati River Originating in the Mahabharat Range

S. No.	Rivers	Length (km)	Altitude at origin (m)
1	Bagmati *Khola*	7.24	2,377
2	Manohara *Khola*	24.14	2,316
3	Dhobi *Khola*	16.74	2,621
4	Bishnumati River	14.89	2,012
5	Balkhu *Khola*	14.48	1,646
6	Nakhu *Khola*	25.10	2,530

Source: Tuladhar 1979

The Bagmati River starts receiving a huge quantity of untreated sewage from dense human settlements as soon as it enters the valley. Skirting the northern boundary of Gokarna Forest, it continues to flow westwards to Pasupatinath. A huge input of sewage occurs about two kilometres upstream from Pasupatinath. Near Sankhamul it joins up with the Manohara River, the biggest tributary in terms of water discharge, and then continues to flow westwards between

Lalitpur and Kathmandu districts. The Dhobi *Khola* enters into the Bagmati at Bijulibazar, the Tukucha *Khola* at Kalmochanghat, the Bishnumati at Teku, and the Balkhu *Khola* at Balkhu. By the time it reaches Chobhar, the Bagmati River has covered a distance of 27km.

The only biological assessment of surface water quality in Nepal was the one conducted by DISVI in cooperation with Royal Nepal Academy of Science and Technology (RONAST) in 1988. DISVI classified the Bagmati River into distinct zones according to water quality classes as defined by the 'Extended Biotic Index'. During recent years, however, in line with the international recognition of biological assessment methods, the importance of such methods has become increasingly clear in Nepal. The interest shown by indigenous writers in the development of limnological research in the country is praiseworthy. An unfortunate side of the research is that no one has yet applied taxonomic knowledge of the macrozoobenthic investigations to the development of a method specific to Nepal. Researchers in the country urgently need a modern, reliable and cheap method of detecting water pollution in order to discover what and where the country's worst problems are and what decisions are needed to relieve people and the environment.

Material and Methods

The basic aim of the present research is a biological assessment of river water quality, with macroinvertebrate communities as the point of reference. Based on the chemical data available and field observations on stream typology, macroinvertebrate communities and their relative abundance, and water characteristics, a quality class was assigned to a particular site based on the saprobic approach cited in Moog (1996). Reference communities were further defined in the laboratory, and the information obtained from this was used to draw comparisons with different biotic indices in use as well as the site reports. These results were compared with those obtained by saprobic methods. In this way the validity of this method of assessing the water quality of Nepalese rivers could be checked.

Sampling Devices

The biotic approach to the biological assessment of water quality in rivers is based on a qualitative or semi-quantitative sampling of the macroinvertebrate fauna. Therefore, a qualitative collection of the macrozoobenthos was carried out with a standard hand net. The net was made of synthetic textile with a mesh size of 100μm connected to a round frame having a diameter of 19cm and manipulated by a handle. The net was connected to the frame by several rings to avoid wear. In addition, metallic sieves of different mesh sizes ranging from one to two mm were also used for collecting fauna inhabiting a sandy or muddy substratum.

Saprobiological Classification of Water Quality

The methods applied to Nepal as described below and cited by Moog (1996) are based on the national and international scientific literature and are the outcome of collaboration on the part of many scientists involved in this field (Moog 1991; ÖNORM 1995).

Water quality class I (Oligosaprobic)
Degree of pollution: None to very slight
Mapping colour: Blue

Xenosaprobic level (degree of pollution: none):
The xenosaprobic river reaches carry clean, always clear (with the exception of glacier-fed brooks), and well-oxygenated water. Suspended organic matter is not detectable. The water is nearly free of natural organic matter. In the substrate no reduction phenomena are visible. The bed sediments are sparsely colonised by algae, mosses, planarians, and other benthic invertebrates (predominantly insect larvae). This water quality class is mostly associated with springs or the upper reaches of extremely clear mountain streams which, due to the fact that their catchment area is characterised by clean rock, channel very clear, clean precipitation and snowmelt water. This unpolluted water quality class is accounted for but in assessment falls into the oligosaprobic water quality class.

Oligosaprobic level (degree of pollution: very slight)
The oligosaprobic level comprises river reaches with clean, clear (with the exception of glacier-fed brooks), nutrient-poor water that is almost always nearly saturated with oxygen. Only small amounts of suspended organic matter or bacteria are detectable. Even fine sediments (*psammal, pelal*) are always of a brownish or light colour throughout and are extremely rich in minerals. No reduction phenomena exist. The substrate is predominantly colonised by algae, mosses, Turbellaria, and insect larvae (in the middle and upper reaches several plecopteran species occur). The fauna are usually species - rich, but low in abundance.

Chironomids are found in sparse numbers; mainly the periphyton-dwelling chironomids (*Diamesinae, Orthocladiinae*). Worms are generally represented by planarians and sensitive oligochaetes. The moss flora are represented by several species, sometimes in high frequencies. Periphyton (predominantly in the format diatoms and cyanobacteria) is noticeably visible, due to its 'colouring'. Green algae are scarce and do not stand out. Oligosaprobic river reaches, given the corresponding availability of structure, contain excellent spawning areas for salmonids and sculpins. This water quality class is associated with spring areas and the very slightly polluted headwaters of summer-cold rivers.

Water quality class I-II (Oligosaprobic to beta-mesosaprobic)
Degree of pollution: slightly polluted
Mapping colour: Blue/green

This transitional water quality class describes river reaches with little inorganic and organic nutrient contents and, with the exception of glacier-fed brooks, clear water. The oxygen content is high. The concentration of suspended organic matter is very low. Fine substrates are of a brownish or light colour throughout; the undersides of stones have no visible black reduction spots. Primarily, these reaches are in salmonid rivers which are densely and diversely colonised by algae, mosses, Turbellaria, Plecoptera, Ephemeroptera, and Trichoptera larvae, as well as Coleoptera (Elmidae, Hydraenidae) and dipteran larvae. Worms are generally represented by planarians and sensitive oligochaetes. Of the leeches (Hirudinea), at most *Dina punctata* and *Erpobdella vilnensis* exist in considerable quantities; net-spinning trichopterans appear only sporadically. The chironomids (predominantly Orthocladiinae and Diamesinae) are slightly more numerous than in water quality class I.

Water quality class II (beta-mesosaprobic)
Degree of pollution: Moderately polluted
Mapping colour: Green

This water quality class is found in river reaches with moderate organic pollution, increased nutrient content, and still with a good oxygen supply (despite possible oxygen supersaturation or depletion). The water in the middle and higher reaches is usually clear and at most contains a low amount of suspended organic particles. In lowland rivers, the suspended solids can increase due to natural processes. The sediment is light or dark, but not black, and is often slippery due to algal growth; the undersides of stones are not coloured with black reduction spots. Processes of biodegradation take place in aerobic areas. Reduction phenomena occur only occasionally, here and there, in lentic sites of potamal waters (e.g., backwaters).

Species diversity and abundance are very high for nearly all animal groups in addition to algae (all groups) and other aquatic plants. The percentage of individuals and the taxon diversity of Chironomidae further increase (predominantly Orthocladiinae, and, in quietly flowing reaches, Tanytarsini and Chironomini). The net-spinning trichopterans are usually numerous only where suitable current velocities are available; Polycentropodidae in particular can appear in large quantities in potamal regions. Macrophytes can cover wide areas, but usually green algae (Chlorophyceae) do not yet appear in large quantities. These rivers yield high numbers of fish of various species.

Water quality class II to III (beta-mesosaprobic to apha-mesosaprobic)
Degree of pollution: Critically polluted
Mapping colour: Green/yellow

This transitional water quality class covers river reaches in which the load of eutrophicating nutrients as well as organic, oxygen-consuming substances is clearly visible. Because of the heavier load of organic matter, the water is, in certain circumstances, slightly turbid. In localised lentic areas, under large stones, sludge may occur. Fine-grained substrates are brown or light coloured at the surface and, in deeper areas, sometimes dark (chemically reduced). Black spots can appear beneath stones. In certain circumstances, and with sensitive species or life-history stages, fish deaths are possible due to strong fluctuations in the oxygen budget. The diversity of macro-organisms is sometimes reduced, and certain species show an abnormal tendency towards mass development.

Macrozoobenthic colonisation by sponges, bryozoans, crustaceans, molluscs, leeches, and insect larvae occurs (among the Plecoptera only certain species of the genera *Leuctra, Nemurella*, and *Nemoura*). Leeches clearly increase. Among the Oligochaetes, on occasion Naididae occur in large quantities. For the first time, Tubificidae occur in remarkable numbers. Net-spinning trichopterans (predominantly *Hydropsyche*) often appear in large quantities, as do chironomids, especially tube-building forms at home in the fine sediments. In addition to the tolerant Orthocladiinae and Diamesinae, in psammal it is the Prodiamesinae that stand out; in pelal the Chironomini (mainly *Polypedilum*), and Tanytarsini (mainly *Micropsectra*). Filamentous algae (e.g. *Cladophora*) and macrophytes frequently form stands covering large areas or develop as mass colonies. Green algae are more abundant than in water quality class II. Sewage bacteria may often be seen as tufts with the unaided eye, but are not yet outstanding. The most diverse group is the ciliates, but colonies of ciliates, that can be seen with the unaided eye, on hard substrates or living benthic organisms, are rare. Usually these river reaches still produce high yields of fish.

Water quality class III (alpha-mesosaprobic)
Degree of pollution: Heavily polluted
Mapping colour: Yellow

Water quality class III is found in river reaches that contain heavy organic, oxygen-consuming loads and usually large oxygen deficits. The water is partially coloured or turbid as a result of suspended matter from sewage discharge. In lentic areas, deposits of sludge are in evidence. Stone, gravel, and sandy substrates usually display blackened spots of ferrous sulphide. In lentic areas, nearly all the undersides of stones can be strikingly black coloured. Fine-grained substrates are often slimy, and in deeper areas black and sludge-like. The fish population is often reduced due to disrupted reproduction; periodically occurring fish deaths can be expected. Only a few benthic invertebrates, which are tolerant to oxygen deficiency, such as sponges, leeches, and aquatic isopods, can occur in large quantities.

Among the worms, Tubificidae dominate, and to some degree Naididae, Enchytraeidae, and the genus *Lumbriculus*. Besides euryoecious Orthocladiinae, the groups of Chironomidae that most often appear are Tanytarsini and Chironomini. Net-spinning trichopterans are strikingly more scarce than in the preceding water quality class, and it is often difficult for the critical pupal stage to survive. The typical ciliate community is composed of *Trithigmostemometum cucullulae*. Colonies of sessile ciliates (*Charchesium, Vorticella*) can be clearly seen with the unaided eye, as can filamentous sewage bacteria and fungi (e.g. *Sphaerotilus, Fusarium*, and *Leptomitus*) which grow on hard substrates and living benthic organisms. Filamentous green algae found in the preceding water quality class mostly give way to *Stigeoclonium*; sewage-tolerant, blue-green algae; and diatoms, which sometimes cover large areas in lentic locations. Sewage-tolerant macrophytes are still able to grow in masses.

Water quality class III to IV (alpha-mesosaprobic to polysaprobic)
Pollution level: Very heavily polluted
Mapping colour: Yellow/red

The river reaches of this transitional water quality class, to a large degree, provide limited conditions for life due to the very heavy loading of organic, oxygen-consuming substances. Occasionally anoxic conditions prevail; the water is often coloured and extremely turbid due to suspended matter from sewage discharges and drifting tufts of sewage bacteria; the river bottom is mostly covered with sludge. Fine substrates in deeper areas are nearly black throughout, sludgy, and occasionally release a clearly detectable odour of hydrogen sulphide. In lentic areas, nearly all undersides of stones are blackened. The most extensive sludge deposits in lentic areas are densely colonised by larval chironomids of the genus *Chironomus*, tolerant Tanypodinae, tubificid worms, and Enchytraeidae (e.g., *Lumbricillus*). In hard substrates leeches can be found; the accompanying fauna are composed of euryoecious species.

Compared to water quality class III, the algal cover is reduced in both qualitative and quantitative terms. In lotic sites, blooms of filamentous, sewage bacteria occur (typical 'sewage fungal-development'), and sulphur bacteria can form striking macroscopic layers. The microbenthos mainly consist of ciliates, flagellates, and bacteria, which often show mass development. The existence of self-sustaining and balanced fish populations is no longer possible.

Water quality class IV (Polysaprobic)
Degree of pollution: Extremely polluted
Mapping colour: Red

Water quality class IV is found in river reaches with an extreme loading of organic, oxygen-consuming sewage. The water is often coloured and extremely turbid due to the suspended matter of sewage discharge and sewage bacteria. The river bottom is usually characterised by heavy deposits of sludge. In lotic sites, nearly all the undersides of stones are covered with large black patches of ferrous (II) sulphide; in lentic areas, both sides of the stones are also totally black. Fine substrates are also totally black. Processes of putrifaction predominate, and there is often the odour of hydrogen sulphide. Oxygen concentrations can be very low, or occasionally anoxic conditions occur. Colonisers are predominantly bacteria, flagellates, and bacteriophagous ciliates, which often develop in masses. The typical ciliate community is *Colpidietum colpodae*. The filamentous sewage bacteria are less abundant than in the preceding water quality class. Sulphur bacteria reach their peak abundance and form clearly visible lawns.

Compared to water quality class III, the algal cover is reduced in both qualitative and quantitative terms. Besides a few chironomids (*Chironomus riparius*-agg. and *Chironomus plumosus*-agg.) and individual tubificids, the macrofauna are only further represented by air-breathing forms (e.g. mosquito larvae, moth flies, soldier flies, and syrphids).

Methods Used for the Description of Sampling Sites

A site report is prepared during biological studies of a sampling site. It contains an aquatic ecologist's subjective impressions of both the sampling site and the biocoenoses and a description of individual sample locations with sketches of the channel profiles. The specifications on the baseline data sheet, especially concerning the condition of the river bottom and riparian zone, and the relative frequency of habitats (choriotopes) are checked at that site as described by Moog (1991) as Austrian Standards.

The site report should contain the following.

- River name, length (km), geographical coordinates, and height above sea level at mean water level (MWL)
- Sample site, date, and time
- Weather conditions (e.g., air and water temperatures, precipitation before and during the survey, snow coverage, ice formation, ground ice)
- Quantitative hydrographic data (e.g., water-gauge level, reference gauging station, and actual discharge, if possible, recorded in a channel profile within the sample location)
- Flow data (mean current velocity within a channel profile, data regarding the observed runoff, both long-term and daily, including whether the runoff is static, increasing or decreasing and the cause of these conditions; at a drawdown operation, data on the tendency of the surge or sinking of the water level as well as data concerning the relationship between the surge peak and the progressive sinking of the water level, description of the flow characteristics at the sample location as shooting, flowing, turbulent, eddying, pressed against a wall or structure, whirling, etc)
- Gradient (slope)
- Channel and riverine landscape morphology
- Colour, turbidity, smell of the water
- Optically visible effects of sewage inputs, such as turbidity, colouring, foam, sewage plumes
- Physico-chemical properties of the water
- Physico-chemical studies should assess the water conditions at the time of sampling. An evaluation of the sediment budget (inputs, outputs) requires that representative samples are taken over time within special study programmes. For the physico-chemical characterisation of a river, the geology of the drainage area, the nutrient load, and the organic load, as well as pollutant loads, should be recorded throughout the course of the yearly discharge.
- Conditions of the river bottom and the percental relative frequency of choriotopes
- Weed growth, algal covering according to substrate, sulfur bacteria, fungi, sewage-relevant bacteria, ciliate lawns, etc

- Colour changes in the sediment (reductions), formation and accumulation of sludge, sediment deposition and removal; visible effects of floods, dredging, and impoundment flushing; macrozoobenthic composition and abundance estimation in different choriotopes, with a separate analysis of at least one lotic and one lentic area
- Others, such as spawning, sick, or dead fish, particular aspects of vegetation, floating solid waste, suspended solids, deposited foreign substances (garbage), or the like
- Draft map, a transverse and longitudinal profile of the sample location, including its distribution of substrates, bank lines, water depth, location of sampling sites for water chemistry, bacteria, ciliates, benthos, algal cover, and sediment chemistry

(1) Method Used in Estimation of the Relative Abundances

The abundance of fauna at a certain site within a section of a river was estimated according to the 1-to-5 Scheme proposed by Schwerdtfeger (1975), as tabulated below.

Table 2: The Abundance Estimation Method (after Schwerdtfeger 1975)

Terms Used	Scales	% Composition in the Sample
Highly abundant	5	more than 15
Abundant	4	15-5
Common	3	5-2
Rare	2	2-1
Very rare	1	1

Processing of the Materials

The processing of the materials sampled was carried out partly in the field and the rest in the laboratory. In the field, the samples collected from different habitats by several persons were transferred to a white enamelled tray and identified. Identification of all the groups of animals was not possible, and hence working names with identifying characteristics were separately mentioned in the protocol. Animals were preserved in 70 per cent alcohol in a plastic container and kept safe with proper corks and within a covering of cotton for transportation.

Results

As shown in the water quality map (Fig. 1), a stretch of the Bagmati River from Sundarijal to Khokana was selected for the present study. Thirteen sites were established along the river, and thirty on the different tributaries. A list of investigated sites is provided in Table 3.

Discussion

The results obtained after the application of the saprobic system during water quality assessment of the Bagmati River in the Kathmandu Valley were compared with the Nepalese Biotic Score (NEPBIOS/ASPT) method. This showed that there exists a highly significant correlation (R^2) of 0.83, as shown in Figure 2.

Table 3: List of Sites Investigated with Water Quality Class at Each Site Compared by Using the Saprobic System and the NEPBIOS-based Average Score per Taxon Method

Name of the Rivers	Locality	Sampling Date	Alt. (m)	Zone	WQC	NEPBIOS/ASPT WQC
Sipadol *Khola*	Jagati, Bhaktapur	12.12.1995	1310	Central	II-III/III	II-III
Mahadev *Khola*	Jagati, Bhaktapur	12.12.1995	1310	Central	II-III	II-III
Hanumante River	Sallaghari, Bhaktapur	12.12.1995	1305	Central	III-IV/IV	III-IV
Khasyang Khusyung	Purano Thimi road, Bhaktapur	12.12.1995	1310	Central	III (-III)	II-III
Manohara River	Sanothimi, Bhaktapur	12.12.1995	1305	Central	II	II
Dhobi *Khola*	Bijulibazar, Kathmandu	13.12.1995	1300	Central	IV	III-IV
Bagmati River	Sankhamul, Kathmandu	13.12.1995	1314	Central	III-IV	III
Bagmati River	Thapathali, Kathmandu	13.12.1995	1312	Central	(III)-IV	III
Bagmati River	Tinkune, Kathmandu	13.12.1995	1315	Central	(III)-IV	III-IV
Bagmati River	Pashupatinath, KTM	13.12.1995	1320	Central	III-(IV)	III
Bagmati River	Sundarijal, Kathmandu	13.12.1995	1450	Central	I-II	II
Bagmati River	Gokarneshwor, KTM	13.12.1995	1365	Central	II	II
Bagmati River	Gokarna, Kathmandu	13.12.1995	1360	Central	II-III	II-III
Dhobi *Khola*	Gyaneshwar, Kathmandu	13.12.1995	1340	Central	IV	III
Bagmati River	Kupandole, Lalitpur	14.12.1995	1311	Central	IV	III-IV
Bagmati River	Teku, Kathmandu	14.12.1995	1310	Central	IV	IV
Bishnumati	Teku, Kathmandu	14.12.1995	1310	Central	IV	III-IV
Bagmati River	Chobharganesh, KTM	14.12.1995	1290	Central	IV	IV
Bagmati River	Khokana, Kathmandu	14.12.1995	1280	Central	III-IV	II-III
Chalti *Khola*	Chalnakhel, Kathmandu	14.12.1995	1365	Central	II	II
Bosan *Khola*	Taudaha, Kathmandu	14.12.1995	1400	Central	I-II	II
Balkhu *Khola*	Khasi Bazar, Kathmandu	14.12.1995	1312	Central	II (?)	III
Balkhu *Khola*	Balkhu, Kathmandu	14.12.1995	1295	Central	III (?)	II-III
Balkhu *Khola*	Kalankisthan, KTM	14.12.1995	1335	Central	II	II
Tukucha *Khola*	Exhibition Road, KTM	15.12.1995	1300	Central	IV	IV
Tukucha *Khola*	Naxal, Kathmandu	15.12.1995	1305	Central	IV	III-IV
Tukucha *Khola*	Bishalnagar, Kathmandu	15.12.1995	1310	Central	IV	IV
Tukucha *Khola*	Tundaldevi, Kathmandu	15.12.1995	1310	Central	IV	IV
Dhobi *Khola*	Chabahil, Kathmandu	15.12.1995	1319	Central	III (?)	III
Dhobi *Khola*	Budhanilkantha, KTM	15.12.1995	1470	Central	II-(III)	II
Bishnumati	Budhanilkantha, KTM	15.12.1995	1470	Central	II	II
Bishnumati	Gongabun, Kathmandu	15.12.1995	1320	Central	III-(IV)	II-III
Mahadev *Khola*	Trishuli Road, Kathmandu	15.12.1995	1325	Central	II-III	II-III
Bagmati River	Sinamangal, Kathmandu	16.12.1995	1317	Central	III-IV	III
Bagmati River	Kumarigal, Kathmandu	16.12.1995	1325	Central	III	III
Nakhu *Khola*	Nakhu, Lalitpur	16.12.1995	1300	Central	II-(III)?	II
Nakhu *Khola*	Okhathali, Lalitpur	16.12.1995	1305	Central	II-(III)	II-III
Khodu *Khola*	Hattiban, Lalitpur	16.12.1995	1360	Central	II-III	II-III
Khodu *Khola*	Lubhu Road, Lalitpur	16.12.1995	1325	Central	(II)-III	II-III
Godawari *Khola*	Godawari, Lalitpur	17.12.1995	1434	Central	I-II/II	II
Godawari *Khola*	Badegaon, Lalitpur	17.12.1995	1405	Central	II-(III)	II
Godawari *Khola*	Balkot, Bhaktapur	17.12.1995	1320	Central	II-III/III	II-III
Hanumante River	Balkot, Bhaktapur	17.12.1995	1300	Central	III-IV	III-IV

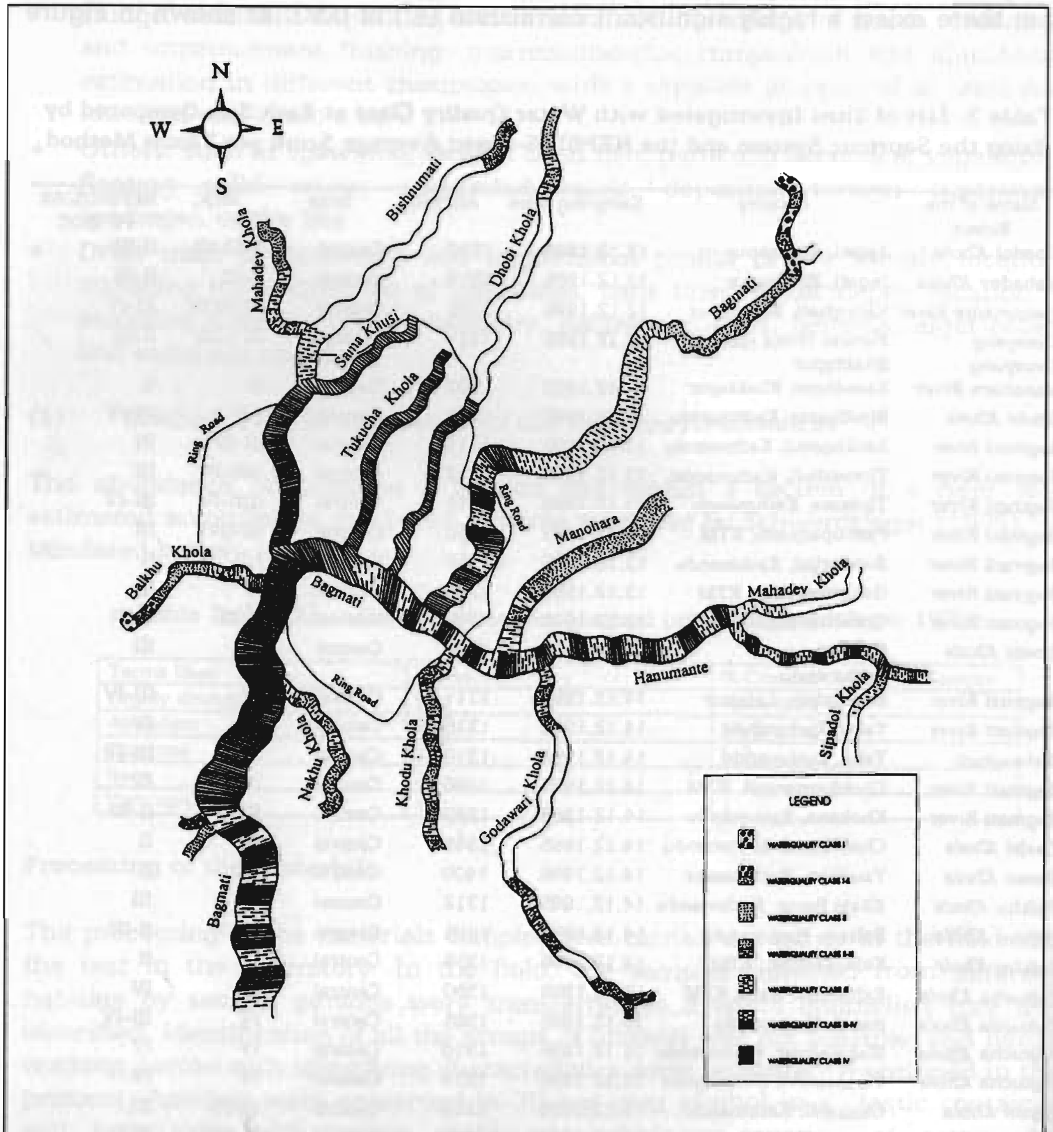

Figure 1: Water Quality Map of the Bagmati River System

With this result, the efficiency of not only the saprobic system but also of the Nepalese Biotic Score (NEPBIOS) in the water quality assessment of the Bagmati River is satisfactorily illustrated. NEPBIOS, as cited by Sharma (1996), has been very effectively applied not only to the Bagmati River, but also to all the major river systems of Nepal. Its efficiency can be further sharpened with the inclusion of site reports and a saprobiological description of water quality, as cited by Önorm (1995) and Moog (1996).

The Bagmati River in its flow through the Kathmandu Valley is now at a stage of ecological collapse. The situation within the Ring Road is deplorable, the water quality there being in an extremely polluted state. The deterioration in water quality is all the more visible for the river having been dammed upstream at Sundarijal for hydroelectric power generation and drinking water supply. A few kilometres downstream it has been further regulated for irrigation and for the running of a mill. Once the river enters the valley, its use becomes extremely diverse, and its water quality deteriorates rapidly.

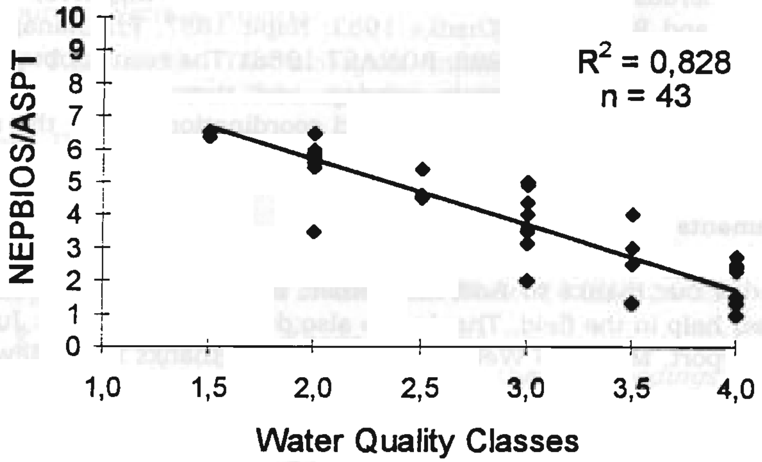

Figure 2: The Relationships between Water Quality Classes Assessed Based on the Saprobic System and the Values Obtained by the Nepalese Biotic Score Method.

The dumping of an unsustainable load of unburned wood and ashes into the river and the bathing and clothes' washing activities and sewage input at Kumarigal and Gaurighat have turned the water quality of the river from III at Kumarigal to III-IV at Pashupatinath. As the river continues to flow through the latter, the country's most religious site, the water quality continues to deteriorate. Nevertheless, people regard the water as holy and use it for drinking and bathing purposes. With the flow of the Tukucha *Khola* into it, the Bagmati River loses its identity, its water is no more suitable for any reasonable purpose. The water quality map presented here clearly illustrates this, and even a layman can see the unhygenic conditions of large numbers of people living within the Ring Road. The water quality was found slightly improved as the river approaches Khokana.

A remonitoring of the water quality of the Bagmati River was carried out in the month of March 1996. The water flow was very slow and nearly stagnant at Pashupatinath and the water quality down to IV, making it in principle unsuitable for any purpose. But still people were drinking the water, and so inviting misery or an untimely death.

The present research revealed that, of the diverse uses of the Bagmati River, its use as a receptacle of raw sewage has been the root cause of organic pollution. No sewage treatment system has been built in the valley, which is inhabited by 1.5 million people. The valley has in recent years been rapidly converted into a jungle of concrete buildings in an unplanned manner.

The Bagmati River has always received the most persistent attention, probably because it is the main river of the Kathmandu Valley and because of its religious importance. On the one hand, it is an open drainage, and on the other, people sprinkle its water in a way in which they think it will bring prosperity and eternal life. Numerous studies have been carried out on this river (Shrestha 1980; Upadhaya and Roy 1982; Khadka 1983; Napit 1987; Pradhananga et al. 1988; Vaidya et al. 1988; DISVI 1988; RONAST 1988). The results obtained from some of these studies unfortunately overlap, and there seems to be some duplication of efforts. Greater cooperation and coordination among the research institutions and individuals should be striven for in future.

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