INTRODUCTION

Planet earth is a blend of living and non-living elements interacting in innumerable ways that result in a variety of landscapes and ecosystems. This amalgam is very dynamic, both in time and in space, and is constantly changing, unfolding and producing new combinations. The living elements – living by nature and their capacity to self-reproduce – come in a great variety of forms, shapes, and complexities, that are continuously changing and evolving, comprising the diversity of life.

Diversity is a property, not an entity in itself. It refers to the property of a set of objects not being identical, of varying one from another in one or more characteristics. When applied to organisms, it refers to the universal attribute of all living things that each individual being is unique, that is, no two organisms are identical. The origin of this variability is to be found in the basic and fundamental property of the DNA molecule. This characteristic combined with natural selection allows the acquisition and accumulation of favorable mutations, and in the approximately 3 thousand years that life has existed on earth, these processes have produced the enormous biological variation that we see today, which is at best only a very small percentage of all the variation that existed in the past. Today this diversity of life is threatened by human activities, although the exact rate of species loss is difficult to ascertain. And species loss is only one aspect of the profound transformation that is taking place, brought about by the growth of human population and their economic activities (Solbrig, 2000).

For centuries, biologists have been interested in the diversity of life forms, and their evolution and extinction. The role of biological diversity in the functioning of different ecosystems has also been investigated for several decades. However, the Convention on Biological Diversity adopted at the Rio Earth Summit in June 1992, has led to a resurgence of interest in the subject of biodiversity and its various human dimensions (Heywood and Watson, 1995; Di Castri and Younes, 1996). The convention requires, *inter alia*, an assessment of the current status of biodiversity in all countries and formulation of integrated strategies for its conservation. Unfortunately, in many countries such as India, even an assessment of the current status of biodiversity has not been completed yet while much noise is generated about the need for conservation and legislative action on matters concerning biodiversity.

Numerous seminars and workshops have concentrated on the biodiversity in terrestrial ecosystem, its conservation in protected areas such as national parks and sanctuaries, and its socioeconomic dimensions, whereas the biodiversity in aquatic ecosystems, especially the freshwaters, where the life first originated, remains neglected. To a certain extent even the marine environment received some amount of attention. However, freshwater bodies with less than 0.2% of the worlds total water resources and disproportionately high biodiversity, have received little attention (Gopal, 1997).

Tropical Asia is poorly known to fresh water biologist (Fernando, 1984). This is especially true of lotic habitats, notwithstanding Dussart's (1974) review of the pre-1970 literature pertaining to tropical Asian inland waters. Tundisi in 1984 wrote of the general perception that knowledge of tropical freshwaters was far less than that needed to understand the mechanisms and processes operating in these ecosystems. A perennial obstacle to tropical research, he added was difficulty in obtaining even the basic literature. Radhakrishna (1984) described limnology in the Indian subcontinent as "a virgin field", stating that "the basic knowledge concerning systematics and ecology of various groups of aquatic animals is still unsatisfactory".

Dudgeon (1995) stated that few, if any, large Asian rivers remain in pristine conditions and in fact most are in parlous state. These great rivers which had once been the cradles of civilization have now been transformed due to Anthropogenic pressure. The extent of past and ongoing human impacts on riverine biodiversity cannot be assessed accurately because we know little of the pre-impact conditions. Pollution from agricultural areas and non-point sources are largely uncontrolled, and domestic wastewater treatment is limited to such an extent that almost all sewage entering the rivers is untreated. Many rivers are in such conditions that fisheries have collapsed. Legislation concerning discharge of untreated industrial effluents has been enacted but is weakly enforced (Dudgeon, 2000).

India is no exception. The country's major and minor rivers along with their tributaries, minor streams, creeks and all other microlotic systems have an estimated combined length of 45,000km. Over the last few decades, marked alterations in the riverine systems have led to deterioration in the water quality and this has been detrimental to the species diversity. With the pollution of rivers and water bodies growing at an unprecedented scale in India, the survival of hundreds of river-based species of plants and animals is gravely endangered today (MoEF, 1999). Excessive exploitation and habitat modification by human beings are readily recognised as major factors causing loss of biodiversity, in the context of aquatic systems. Disposal of domestic and industrial effluents in waterbodies is one of the most serious threats to biotic diversity in India (Gopal, 1997).

The freshwater bodies in Gujarat may be amongst the most polluted inland water bodies in India. With a series of industries, predominantly chemical industries, along the Vapi – Gandhinagar belt, locally known as 'Golden Corridor', the surface and ground water in this region are subjected to heavy pollution. Moreover, due to rampant mushrooming of human settlements around industries, the need for freshwater in this region is escalated manifold in the last couple of years. This dual act of pollution and over exploitation has reduced many of the rivers in this region to mere waste channels of domestic and industrial effluents for most part of the year.

River Vishwamitri is one such river, which flows through the city of Vadodara and bisects the city into two halves. This river was once the lifeline of the people of Vadodara city. Like many places in India, the city of Vadodara had a sacred relationship with the river, which is apparent in the number of temples and ghats occurring along the riverbanks. There are early watercolors showing the area being used by worshippers for praying and bathing. The city developed on the very banks of this river. The city still continues to expand and so does the population. Due to the rapid industrialization more and more people have migrated to the city and the population continues to increase This has not only burdened the existing resources, but has also modified the natural physical processes significantly.

Though there are three sewage treatment plants in the city, none of them is capable of taking the load (Vision Vishwamitri, 1996). As a result the sewage gets dumped into river Vishwamitri. This has resulted in severe deterioration of the water quality. An expected consequence of this degradation would be the change in the biodiversity of the river. Thus this study was undertaken with the aim to understand the existing status of biodiversity of the river.

OBJECTIVES

The perusal of literature showed that previous studies on River Vishwamitri were concentrated on the algal flora and its ecology (Nandan and Patel, 1983a; Nandan and Patel, 1983b; Sharma, 1985; Nandan and Patel, 1986; Nandan and Patel, 1991). No composite study, either short term or long term had ever been carried out on any other component of Vishwamitri River. The first objective therefore, **was to identify the different life forms and enlist them** (Chapter 1). This included making a bioinventory of the riparian zone as well as the stream Both the floristic as well as the faunal components were included. A long list of names of plants and animals makes reading laborious. However, listing of these life forms is necessary for knowing what is present today, and later a similar list will make it possible to evaluate the nature and extent of changes that have taken place.

Identifying the dominant zooplankton community present in the River Vishwamitri was the next objective of this study. This was easily attained by repeated surveys, through which it was learnt that the rotifers formed the dominant community in the river Studying the **species composition of the rotifer community** in the River Vishwamitri was the next major objective. This was much needed since hardly any attention has been paid to the rotifer fauna from Gujarat State. Except for Wulfert's study nearly four decades ago, no other taxonomic work on the rotifers from Gujarat has ever been carried out.

As the river flows from its source to the point where it ends, it flows through the city and as a result of this there is a difference in the quality of the water in the upstream, mid stream and downstream regions. Moreover, the rotifer community may also be sensitive to the seasonal changes occurring in the water. Thus the next objective of this study was **to assess the structure and dynamics of the rotifer community as well water quality** at selected sampling points during all the major seasons of the year.

STUDY AREA

LOCATION AND TOPOGRAPHY (Figure i)

Desai and Clarke (1923) in 'The Gazetter of Baroda' state that the River Vishwamitri takes its origin from the hills of Pavagadh, which is about 43Km away from the Northeast of Vadodara City. A few miles upstream from the spot on which Vadodara stands and not far from the village of Vishveshwar, Vishwamitri river is joined by another stream called 'Surya' which also originates from Pavagadh, a little to the south of the Vishwamitri. Another rivulet called Jambua joins Vishwamitri near Makarpura. The river then continues its course in southerly direction till it joins the Dhadhar river at Pingalwada, approximately 24Km south of Vadodara.

In the district of Vadodara the River Vishwamitri enters the Waghodia taluka and flows past Sarnej, Asoj, Jarod and Kamrol Villages. Thereafter it enters Vadodara taluka and passes by Dena, Harni, Sama, Chhani, Vadodara, Bhayli, Makarpura and Varnama villages. Then it enters Padara taluka and touches Husepur and Virpur villages. Lastly the river traverses the Karjan taluka and it meets the river Dhadhar near village Pingalwada. Of its total length of about 90Km, it flows for 58Km through Vadodara district.

MYTHOLOGY

About the origin of the river, the 'Skandha Purana' gives the following legend:

A pious Brahmin, who long ago dwelt in Champaner, situated in the Shankar forest, resolved one day to cut his head and offer it to God Shiva, here known as Kapileshwar. But god prevented the blood falling on him, sank deep into the earth and so created a great void. Into this yawning gulf once fell the sacred cow, Kamdhenu, of the sage Vishwamitra. To rise to the surface again she sought advice of the god, who told her to let the milk flow from her udder till she floated to the surface. To prevent a similar accident from recurring, the sage ordered the Himadri Mountain to throw itself into the gulf. It did so, but its square summit remained above the plain. Kapileshwar mounted on its summit, now known as Panchmukhi and the Ratnakar, who accompanied Himadri when he jumped into the hole, now takes the name of Ratanmala range.

The sage Vishwamitra, at the desire of the people of Shankar forest cursed and destroyed the demon Pavak (Pavagadh) and blessed the whole river. Rama and Lakshman visited him on their return after their victory against Ravana, and on that occasion Vyas and other sages came to see Vishwamitra at Vyaseshwar. Meanwhile Rama flayed the demon Hiraniksha at the spot now known as Harni, but his teeth were left at the village called Danteshwar. Kamnath, to the north of Harni is another famous place where Shiva supposedly blessed his devotees for bearing sons. Also the bones of the dead, thrown into the Vishwamitri near this spot are blessedly dissolved into the water (Rajyagor and Tripathy, 1979).

GEOLOGY AND GEOMORPHOLOGY

Vishwamitri River arises from Pavagadh hills, 44Km NE of Vadodara, at an altitude of about 600m. Pavagadh hill is its catchment area, made up of basaltic rocks of Deccan Trap Formation. Several horizontally bedded lava flows are exposed in Pavagadh. The hill is 5Km long and around 5Km wide and consists of several scraps separated by extensive plateaus. It shows terraced appearance on account of the differential weathering of the horizontally disposed constituent rocks. These rocks are derived from a complex assemblage of diverse derivatives of one or more parent magmas. The hill represents a horst uplifted on account of North-northwest – South-southeast and West-northwest – East-southeast trending faults. The trappean rocks here rest partly over the quatrzitic rocks of Champaner Group and partly over the Bagh sandstones. Pavagadh is supposed to lie along a major East-West rift zone related to Narmada geofracture system, along which lie the important differentiated alkaline complexes of Girnar, Osham, Barda and Chamardi-Chowghat hills of Saurashtra. Perhaps, Pavagadh hills form the easternmost extremity (Vision Vishwamitri, 1996).

The Vishwamitri River flows for most of its length through Gujarat Alluvial Plains and meets the Dhadhar River at Pingalwada. The alluvial plain of Vishwamitri is made up of loose sediments of gravels, sands, silts and clays. The river does not follow the SW regional slope of the area, instead it follows North-northeast – South-southwest slope deviatory course along a major lineament in the alluvial area. Ravines are conspicuous in the alluvial reach of the river. The drainage is sinuous and seems to be controlled by subsurface lineaments and faults in the area. The river shows deep incision and entrenchment of 10-11m in its meandering channels. The drainage basin is conspicuous by its asymmetry with the tributaries like Surya and Jambua rivers joining it from the left bank only (Vision Vishwamitri, 1996).

PRESENT DAY USAGE

This river has been reduced to a sewer used mostly for dumping the wastes. Only the initial 25Km stretch of the river is used for domestic purposes. The villagers around this part use the water for bathing and washing. This water is also used for irrigation purposes in the fields. Water is directly pumped from the river and used in the fields. Due to this, however, the river dries up by the advent of the summer. The middle stretch of the river, which flows through the city of Vadodara, is used as a drain for dumping the sewage. Thus the water gets increasingly polluted as it moves beyond the city limits. The villagers downstream have also been found to use this water for irrigation purposes.

INTENSIVE STUDY AREA

The entire stretch of the river was traced through a reconnaissance survey to select the suitable sampling stations. Considering the short length of the river five sampling stations were selected in a manner such that two were in the clean zone of the river, two in the septic zone and one in the recovery zone. Later however, it was realized that no true recovery zone exists for this river. As far as possible equal distance was maintained between all the stations.

The five sampling stations and their location obtained with the help of a Geographical Positioning System (*Garmin, GPS 12XL*) are as follows:

Station I: Baska (Figure ii, vii): (Position: N – 22° 28.088'; E – 073° 27.079'; Altitude – 104m)

This is the first upstream station near the foothills of Pavagadh. Here the water exists for most part of the year except in the month of May when the river dries up completely. By the end of June, the monsoon water begins to flow through the riverbed again. The river remains in the flowing condition for about 4 months. By the end of November the water stops flowing and slowly and steadily stagnation sets in and the water level begins to reduce till only small pools exist in the river bed till the end of April.

Station II: Haripura (Figure iii, viii): (Position: N – 22° 27.026'; E – 073° 19.361'; Altitude – 62m)

This is the second station in the upstream part of the river. Water exists at here for a very short duration of time. With the onset of the monsoon by mid June, the water begins to flow through the river. This condition remains till the end of October. Later the farmers along the banks begin to use this water for cultivation and all the water is pumped out of the river, thus causing the river to dry up by the month of January.

Station III: Sama (Figure iv, ix): (Position: N – 22° 20.260'; E – 073° 12.301'; Altitude – 46 m)

This station lies with the Vadodara city limits. Water exists at this site throughout the year on account of the sewage water that is released from the city into the river. For most part of the year the water remains flowing except during the summer when the water level recedes. This site supports a fairly good population of aquatic vegetation.

Station IV: Munjmahuda (Figure v, x): (Position: N – 22° 17.093'; E – 073° 10.314'; Altitude – 43m)

This site lies at the point where the river begins to exit from the city limits. The water is in a flowing condition throughout the year. River at this point receives high amount of sewage that is evident from the black colour and the strong distasteful odour the water exudes. The aquatic vegetation is non-existent at this station.

Station V:) Karari (Figure vi, xi) (Position: N – 22° 10.755'; E – 073° 08.730'; Altitude – 40m)

This is the last sampling station and is located outside the city limit, after the river passes through the industrial sector of the city. The water is in a flowing condition throughout the year. This would otherwise have been the recovery zone, however, right up to the very end of the river, wastes are dumped and the river gets no time for recovery.

CLIMATE AND SEASONS

The climate varies considerably during the different seasons. In general it is dry and hot during most part of the year. The weather is pleasant only during the winter and the monsoon (Table I).

Based on the climate, different seasons were observed during the study period (2000 – 2001) and are classified into the following four:

Summer (March, April, May): This was the season with the maximum average temperature of 40°C. Two premonsoon showers were received during this season with an average of 28.5mm and 36.6mm rainfall.

Monsoon (June, July): This season was characterized by heavy rains. Total rainfall during this season was 347.6mm. The average daytime temperature was about 30.7°C.

Postmonsoon (August, September, October): During this season the last few showers of monsoon rain were received in the months of August and September. The total rainfall for this season was about 56.2 mm. The average daytime temperature was about 35.6°C.

Winter (December, January, February): This season was the coldest period of the year with the minimum temperature falling to 13.7°C.

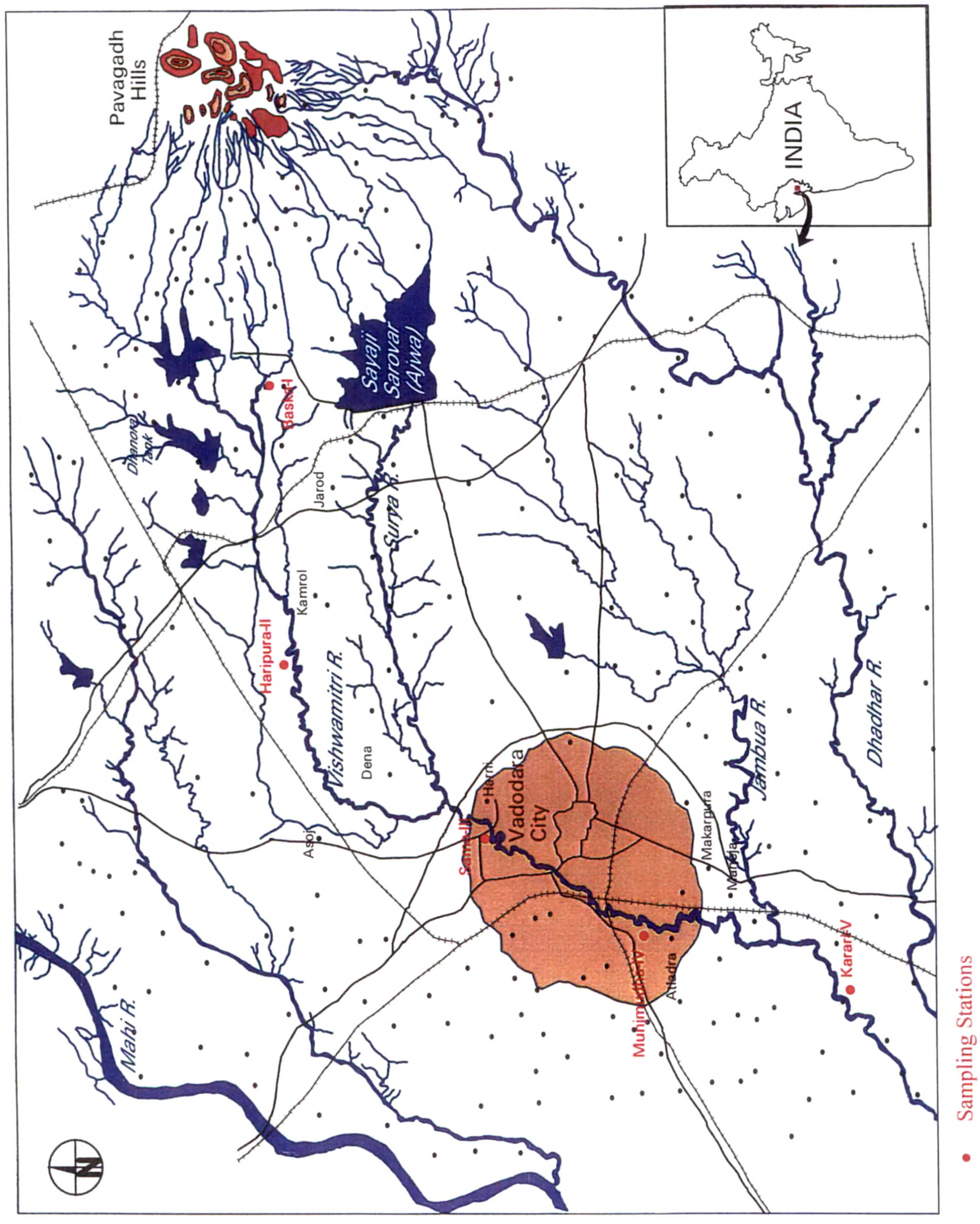
RAINFALL

This area generally receives a rainfall of about 80-90cm however, during the present study the rainfall was far below the average. Only 45.04cm of rainfall was recorded during the study period. The maximum rainfall of 28.8cm was received in the month of July (Figure xii).

TEMPERATURE

The maximum temperature varied between 29.6°C in the month of January to 40°C in April. The minimum temperature ranged between 13.7°C in the month of December and January to 27.6°C in the month of June (Figure xiii).

FIGURE i Location map of study area and sampling stations



FIGURES ii-vi Sampling stations during the summer season

Figure ii. Station I

Figure iii. Station II

Figure iv. Station III

Figure v. Station IV

Figure vi. Station V

FIGURES vii-xi. Sampling stations during the postmonsoon season

Figure vii. Station I

Figure viii. Station II

Figure ix. Station III

Figure x. Station IV

Figure xi. Station V

TABLE I Mean monthly temperature and rainfall data of Vadodara City during the tenure of study (2000 – 2001).

Month	Average Maximum Temperature (°C)	Average Minimum Temperature (°C)	Total Rainfall (mm)
2000			
March	36 2	19.8	
April	40.2	24.9	
May	36 8	26.4	73 2
June	36.0	27.6	81 6
July	32 3	26.7	266 0
August	33 4	27.4	52 4
September	35 1	26.9	3 8
October	38 3	25.7	
November	35 1	20.4	
December	32 1	13 7	
2001			
January	29 6	13.7	
February	33.1	15.6	

Figure xii. Mean monthly rainfall for the year 2000-2001

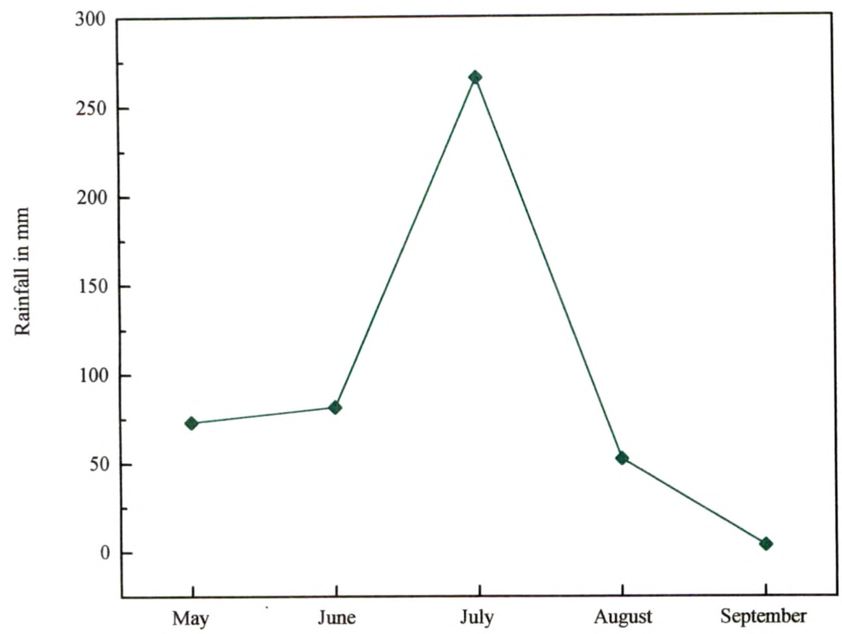


Figure xiii. Mean monthly ambient temperature for the year 2000-2001