CHAPTER I

METHODS AND MATERIALS

" Is it possible to sustain dovelopment .....
so that we can safely live together for ever "

PURPOSE OF INVESTIGATION

Survival in this competitive world, has thrown the *Homo sapiens* into a mad rush, which has been manifested in his ever increasing developmental activities in various fronts. In the process, he has become oblivious (or pretend to become so !!) of the danger made to the natural environment. In this context, the term Geo-environment serves to connote a very special meaning which Keller (1985) defined as " the entire spectrum of human interactions with the physical environment".

Over the last two decades uproar against the geo-environmental degradation and concern for its betterment have occupied major part of our daily news headlines and various research articles. A closer look at these issues reveal that the river basins constitute the major target areas for such hue and cry about environmental degradation. One such area in Gujarat is the Bhadar river basin on which the present thesis dwells.

The river Bhadar, flowing towards south-west, in Saurashtra receives effluents from the dyeing and printing industries located on the bank of the river, at Jetpur. Lack of conscience on the degradation of environment, on account of dye waste disposal, has made Bhadar a menace in the socio-cultural lives of the Kathiawaris. This thesis has therefore been conceptualized, to investigate the effects of the effluents on the geo-environments of the Bhadar valley.

LOCATION

The study area (Bhadar basin) covering 6743.75 sq.km., lies in parts of Rajkot, Junagadh and Jamnagar districts of Saurashtra (Fig. 1.1). The basin falls between Latitude 21° 27' 11" & 22° 11' 21" N and Longitude 69° 45' & 71° 18' 53" E, and forms part of Survey of India toposheet 41/J,K,G,O and N of 1:250,000 scale. The national highway no. 8B, cuts across the basin connecting Rajkot and Porbandar. Apart from this, many state highways criss-cross the valley.

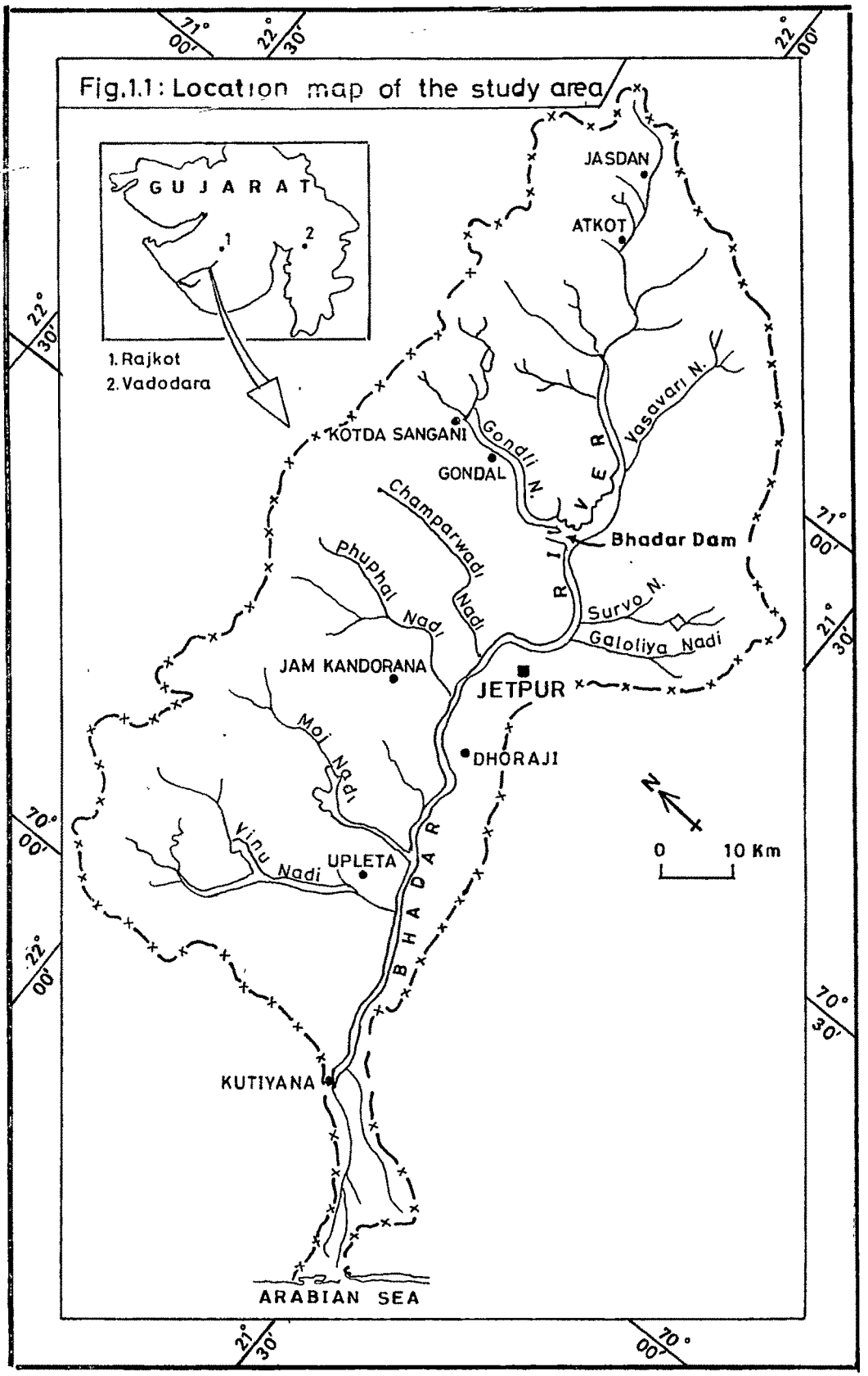
Fig.1.1: Location map of the study area
GUJARAT
1
2
1. Rajkot
2. Vadodara
JASDAN
ATKOT
KOTDA SANGANI
GONDAL
Gondli N.
Vasavari N.
RIVER
Champarwadi Nadi
Phuphal Nadi
Bhadar Dam
Survo N.
Galoliya Nadi
JAM KANDORANA
JETPUR
DHORAJI
Moj Nadi
Vinu Nadi
UPLETA
BHADAR
KUTIYANA
ARABIAN SEA
N
0
10 Km
71° 00'
22° 30'
22° 00'
22° 30'
71° 00'
21° 30'
70° 00'
22° 00'
70° 30'
21° 30'
70° 00'

OBJECTIVES

Looking into the aforesaid condition in the Bhadar river valley, the research was carried out to delineate the deterioration and damage caused at large to the environment. The investigation aims at

* understanding the geology and geo-environment,
* identifying the pollutant source ,
* bringing out the type of pollutants,
* estimating the contaminants added to the surface water of Bhadar river valley and the sub-surface water of the basin and
* thereby assessing the water quality and subsequently delineate the damage-prone aquifer zones,
* studying the water quality for domestic, industry as well as irrigation purposes,
* evaluating the impact of this water on human health and
* suggesting a mitigation.

METHODOLOGY

Keeping the above objectives in mind, the following methodology was designed to solve the problem.

All available secondary data were collected from various government and non-government organizations. The data pertain to the soil, meteorology, water table, the quality and quantity of water, number of sub-surface bore holes within the Bhadar basin.

Recconoitary survey was conducted mainly to assess the geo-environments of the Bhadar basin. During this survey, the geology map (complied and prepared from Imagery and earlier works) was checked on the ground.

While assessing the geo-environment of the basin, the following maps were prepared from the toposheets (1:250,000) and /or from Landsat Imagery of different dates (NRSA dated 22/10/80 MSS 5 and 7; IRS 1 A FCC Bands 234 dated 16/3/90, 25/3/91 and 26/3/91 of 1: 250,000) and were thoroughly checked on the ground.

a) Geomorphology map
b) Drainage map
c) Slope map
d) Landuse pattern map
e) Lineament map

Soil map was prepared from the secondary data of Gujarat Agriculture University (G.A.U.) unpublished report, Soil Survey Organisation (1979), NBSS & LUP of Nagpur (1994) and Kalyanasundaram and Patil (1995).

After considering lithology, structure and geomorphology, the hydrogeological condition of the basin was worked out. While studying the hydrogeological aspects, the sub-surface geology, slope and fractures, the various secondary and primary data on water table, precipitation, recharge, discharge, and soil thickness were analysed and incorporated. To understand the aquifer conditions, a ribbon diagram was prepared covering maximum points spread over the basin.

Evaluating the basin, it was felt that, the quality of water is the major issue, may be on account of the Jetpur dyeing and printing industrial effluents entering into the river Bhadar. Therefore, an attempt has been made to analyse the water. Accordingly, detailed pre and post monsoon sampling of surface water from various fixed locations more or less uniformly distributed along the Bhadar valley and also sub-surface water sample in the same manner for the basin from 1993 to 1995 were collected. In all 50 locations were fixed and the water samples were collected and analysed following the standard procedures.

The analytical data were, further, statistically analysed. The results were compared with control points within the basin and also with the set of standards for potability, irrigation and industrial use.

Finally, method of mitigation is proposed.

PREVIOUS WORK

Literature on the works of the study area and relevant literature, having some resemblance with the present problem have been reviewed. Vast literature are available in one or other aspects on geo-environments or the quality of the water in terms of various parameters of various rivers in India or the same river at different points. Further, the pollutants may be on account of natural or anthropogenic influence, which may be a simple municipal waste or industrial waste or agricultural fertilizer or combination of more than one.It may not be possible for the author, to review all the works seperately in this thesis. He has, therefore, tried to present an over-view of the status of researches in these areas. Some of the references, intensionally omitted in the present chapter, have been incorporated in the proceeding text to stress on one or other points of the work. The reviewed relevant literature have been categorised into three major group as per

1) Geo-envoironmental aspect,
2) Hydrogeological aspect and
3) Quality of the water.

GEO-ENVIRONMENTAL ASPECT

Endogenic and exogenic processes acting on the earth, play an important role in changing the terrestrial environment. Extensive works on geo-environmental aspects covering national and international arenas are available. It is not possible for the author to review the whole work on the geo-environmental aspects in this dissertation. However, he has mentioned some of the works in the later part, where he stresses upon his points of arguements. There is no significant research in the Bhadar valley, barring the water quality, which have been incorportated elsewhere.

HYDROGEOLOGICAL ASPECT

Ninety eight percent of the Bhadar basin, is occupied by basalt and its varities. Therefore, the author made an attempt to review the works which deal with hydrogeology of basaltic terrain. Within the Indian context, Karanth (1990) has brought out the principles and concepts of hydrogeology with case histories. It is mainly based on his personal experience as a hydrogeologist in Central Ground Water Board (C.G.W.B.).

Kulkarni and Deolankar (1989), Rana and Vishwakarma (1990), Thorat and Sable (1990), Murthy (1990), Kulkarni,G.R. (1990), Kulkarni, P.N. (1990), Haseeb (1990) have worked out the hydogeological characteristics of the basalt and have suggested various methods for artificial recharge in the trappean terrains.

Based on the systematic hydrogeological surveys carried out by C.G.W.B., Phadtare (1989) has brought out an unpublished report on the geohydrology of Gujarat. He has discussed, at length, the geohydrology i.e. water quality and water table levels in drought prone areas. Further, he has suggested various methods of artificial recharge. In simillar manner, Narmada and Water Resource Development (N&WRD, 1992) has estimated the ground water resources, recharge, discharge and irrigation potential of the Gujarat State in their report.

Charlu and Dutt (1982) have briefly outlined the hydrogeological conditions of coastal Saurashtra, giving emphasis to the problems of salinity ingression along the coast. Their studies are mainly based on the C.G.W.B. data.

Mendhekar and Pandey (1976) and Bagade (1983) studied the hydrogeological conditions along the Saurashtra coast and stressed on the water quality and artificial recharge techniques.

Parikh et al. (1989), Merh et al. (1989) and Merh and Laghate (1989) have suggested the locations for ground water potential regions in the Saurashtra. Their studies were based on the remote sensing techniques and geophysical data.

Besides these, wealth of field data pertaining to hydrogeology of the Bhadar basin are available in the form of progress reports and monitoring reports of the State Government (Gujarat Water Resource Development Corporation G.W.R.D.C. and C.G.W.B.).

QUALITY OF THE WATER

During the last three decades, awareness among the scientists on the quality of water has made them to understand the type of pollutants, their causes and their impact on the life. Among the surface water quality, researches were done on the water of Ganges and its tributaries by various workers (Handa,1972; Sharma and Sharma, 1981; Agrawal et al., 1982; Das Gupta, 1984; Sankar Narayan and Madhyastha, 1985; Ajmal et al., 1985a and 1985b ; Bhargava, 1985; Singhal et al., 1987; Shukla et al., 1989; Das and Sinha, 1993; Mukherjee et al , 1993; Israili and Ahmed, 1993; and Singh and Singh, 1995)

The essence of these works points to the causes for pollution as i) the industrial effluents meeting the Ganges, ii) the municipal wastes dumped, iii) half burned human bodies and ashes, and iv) domestic usage of the river. These pollutants increase the biological factors, chloride, hardness, sulphate, nitrate, phosphate, fluoride, sodium, electric conductivity, total dissolved solids and many other toxic elements. It is interesting to observe that the values fluctuate, depending on the seasonal variation on account of dilution (Handa, 1972).

Subramanian and his students have worked out on the suspended sediments in various Indian rivers and the various ions present in the natural course (Subramanian, 1976, 1979a, 1979b, 1993, 1994; Bikshamiah and Subramanian, 1980; Ramesh and Subramanian, 1985; Subramanian et al., 1987a, 1987b ; Singh and Subramanian, 1988; Ramesh et al., 1988; Ramanathan et al., 1988; Vaithiyanathan et al., 1989; Jha et al , 1990; Subramanian and Mohanachandran, 1990; Biksham et al., 1991; Chakrapani and Subramanian, 1993; Gupta and Subramanian, 1994; Panda et al., 1995). Their contributions are unique and pioneer in the national scenario. They have discussed the metal absorption capacity of the fine clays carried by various rivers.

Sahu and his students have investigated the Ulhas river water qualities near Mumbai (Sahu and Mukherjee, 1983 and 1985). They concluded that the contamination is on account of disposal of effluents from industries to the river. The suspended fine sediments in these river, is of smectite which absorbs many toxic heavy metals.

The relation between the sediment characters, mineralogy and heavy metal distribution in various rivers have been studied by De et al. (1982), Mehrotra (1986), Saikia et al (1988), Israili (1992). These works suggest that the sediments have high concentration of the metal pollutants.

Evaluation of the quality of water is determined by its chemical, physical and biological properties. When it comes to the quality of the ground water, it is utmost important to study the source and environment of ground water occurrence, source of pollution and other related aspects. Hither-to, number of workers have investigated on one or more parameters, their concentrations and the causes (Olaniya and Saxena, 1977; Krupanidhi, 1984; Ramesan and Rajagopalan, 1985; Lakshmanan et al., 1986; Rao et al., 1986; Ghose and Sharma, 1986; Singh et al., 1987; Handa et al., 1988; Karkar et al., 1989; Handa, 1992a, 1992b, 1993; C.G.W.B., 1991; Hegde et al., 1992a, 1992b; Prakash et al., 1992; Elango et al., 1992; Ozha et al., 1993; Gupta et al., 1993; Rao et al., 1993; Hegde and Puranik, 1994; Seth and Singhal, 1994; Chowdhary et al., 1994; Sikdar et al., 1994; Singh, 1994; Mittal et al., 1994,; Singh et al., 1994; Mehta et al., 1994; Pandey and Mukerjee, 1994a, 1994b ; Chari and Lavanya (1994); Badve and Welekar (1994). In a nut shell, what one understands from the above literature is that the anthropogenic interference disturbs the natural eco-system, which inturn is controlled by the weathering profile, fracture pattern, lithological condition of the area and influence of the quality of the ground water.

Yet another intresting area of investigation is the coastal tracts and its salinity ingression problems Many workers have studied the ground water conditions on the Coramendal coast (Deshmukh et al., 1973; Deshmukh and Karanth, 1973; Chowdary and Radhakrishna, 1993; Lawrence and Balasubramanian, 1994a, 1994b; Subramanian and Balasubramanian, 1994), Malabar coast (Deshmukh and Karanth, 1973), Konkan coast (Deshmukh and Karanth, 1973) and Gujarat coast (Mendhekar and Pandey, 1976; Desai et al. ,1979; Ahluwalia, 1983; Bagade, 1983; Bhandari et al., 1986; Mistry, 1989; Muthuraman et al., 1992). The salinity ingression along the coastal areas of Saurashtra is on account of over irrigation (Govt. report, Charlu and Dutt, 1982; Karanth, 1979; Karanth, 1990). Sahu and Karim (1989) have reported high concentration of fluoride in ground water from Amreli and concluded that it is due to the leachable fluoride absorbed in soil and clay. Phadtare (1989) has also confirmed the high concentration of fluoride in ground water of Amreli.

Coming into the thrust area of dye industry and its effuents, voluminous works have been done. Among them notable are Mundri et al. (1970), Kothandaraman et al. (1976), Ghate et al. (1979), Govindan and Sundaralingam (1979), Manjunath and Mehrotra (1981), Ajmal and Khan (1985), Mc. Kay and Al Duri (1988), Demkin and Uhrich (1988), Schwarzlmuller and Brisse (1988), Gharia et al. (1988), Rajan (1989), Rao et al. (1993), Shukla et al. (1994), Lin and Peng (1994) and Mall and Upadhyay (1995).

STUDY AREA

Well documented research papers on the relationship between Jetpur dye industry and the Bhadar river water qualities have been brought out by Parikh et al. (1990), Ruparelia et al. (1993), Ghosh et al. (1993), Raiyani et al. (1994), Nair and Ganapathi (1995), Nair and Ganapathi (press).

Ruparelia et al. (1993) have investigated the biological parameters of the Bhadar river water between Jetpur and Dhoraji and suggested that their high values are on account of dye industrial pollution.

Ghosh et al. (1993) have carried out microbial analysis of the Bhadar water and discussed about the toxicity.

Raiyani et al. (1994) studied more on physico-chemical and biological parameters of the Bhadar river water and concluded that the river water is a polluted one.

Nair and Ganapathi (1995) analysed the surface water of Bhadar river in terms of its pH, BOD and COD and stated that their higher values are on account of the dye industry effluent wastes which are added to the river. Further, they have suggested some mitigatory measures. Nair and Ganapathi (Press) have discussed in detail the Bhadar river water and its utility for agricultural purpose.