Chapter – 1

Introduction

1.1 Introduction:

Water is a prime natural resource that is an essential component for all life forms on the earth (Buchholz, 1998). It plays a major role in water supply, ecosystem functioning and human well-being (Sheikhy Narany et al. 2014). Lot of attention has been drawn towards the surface water quality. It is largely because it strongly influences human activities. Subsurface water quality and quantity is a subject of worldwide concern (Villeneuve et al. 1990; Isa et al. 2012). This resource is sometimes inadequate, sometimes abundant and is always unevenly distributed over space and time. It is required for different purposes like industries, agriculture, domestic, generation of electricity, irrigation, fishing etc. It's use and usage has grown recently, it's usage has increased and with the growth of industrialization and urbanization the trend will continue (Pius et al. 2012).

Surface and sub-surface water are the two types of water resources. These are not separated constituents of the hydrologic system, but they interact in a variety of physiographic and climatic landscapes (Shittu et al. 2008). Both of them are also exploited in order to fulfil the expanding requirements of the people, community and region. High dependency on water resources has put a lot of pressure on them (Ghosh and Kanchan, 2014).

In recent years, the surface water has been given more attention because the quality of water strongly influences human activities. It should be preserved at a certain level (Filik Iscen et al. 2008). On one hand, when it plays a major role in the development of the country/region/area but on the other hand, it would gradually deteriorate due to excessive use in irrigation, fishery, domestic usage and industrial sectors. The pollution of surface and subsurface water by industrial effluents, domestic sewage and agricultural runoff has increased immensely (Varsani and Manoj, 2015). In addition, due to increased industrialisation of the coastal areas has resulted in the degradation of ecosystems and reducing the living resources.

Sub-surface water is one of the most significant resources which is used for several designated uses particularly for drinking purposes mainly because it is considered to be contamination free and less polluted than surface water (Sharma, 2015; Khakhar et al. 2017). It's occurrence depends on physiography, rainfall pattern, geological structure and weathering. The interaction of these physical factors generates complex hydro-geological environments with varying quantity and quality of water and also help to renewability of sub-surface water resources (Cobbina et al. 2012).

However, sub-surface water may get polluted because of infiltration of pollutants such as wastes from industries, agricultural runoff, septic tanks, sewage system or other treatment systems and different anthropogenic activities on land. In addition, overexploitation of sub-surface water can have an impact on both the quantity and quality of water.

According to Piscopo (2001), the contamination of sub-surface water depends on the pollutants which percolate and reach the aquifer table. It causes transformation in the physico-chemical parameters of water, which disrupts biological ecosystems. These hazardous changes in the natural condition of ecosystems have significant consequences for both the biotic and abiotic components of the environment (Varsani and Manoj, 2015).

Hence, several factors, including the discharge of industrial and domestic waste, mining sites, solid and liquid waste disposal from industries, ship breaking yards, excessive use of pesticides and fertilisers, animal manures, sewage sledge, combustion of fossils, spillage of chemicals and petrochemicals, fibers, polymers, and so on, have all had an impact on water quality.

Natural contamination of water resources mainly occur from geological phenomena such as ores, fluorides, calcium and sulfate often found in rock (Al Fraij et al. 1999). They interact with water, causing chemical reactions and pollute sub surface water. However, it is observed that anthropogenic activities are the main responsible factor for the quality of surface and sub-surface water (Sillanpää et al. 2004).

Seawater intrusion is another phenomena that occurs in coastal aquifers and this also leads to a greater threat to the quality of water in coastal areas (Amer, 1995). Geological settings, hydraulic gradient, excessive withdrawal of sub-surface water that significant decrease the recharge rate contributes to the problem (Pujari and Soni, 2009). Thus, surface and sub-surface water quality is a significant issue that must be monitored and analysed. The Water Quality Index (WQI) is one of the most effective ways for detecting and monitoring the quality of surface and subsurface water.

Industrialisation is one of the important phenomenon which ignites the mechanism of development. The process of industrialisation accelerated in the later part of the 18th century after the advent of industrial revolution. This phenomenon created job opportunities, increased per capita income, enhanced literacy rates, skill and infrastructural development etc. On the other hand, it is also responsible for excessive depletion of resources, crowding of people in few pockets, exerting pressure on existing infrastructure, ecological dis-balance etc. Eventually, both organic as well as inorganic environment gets affected. Industrial activities like manufacturing of fertilizers, cotton products, chemical and petro-chemical, rubber, oil refinery, plastic and paper products etc. generates hazardous industrial waste and dispose in the vicinity areas that adversely impact the environment such as contamination of air, soil and water.

Much of studies have observed that, around industrial areas high concentration of different chemical parameters such as mercury, lead, fluoride, total dissolved solids, potassium, nitrite, calcium and sodium are found in water and soil. Drinking water which has elements more than the desirable limits or less than the permissible limits adversely affects human health. On continuous consumption water with elements exceeding the desirable limit can cause various human health problems. According to Xu et al. (2019), in China, disorders of the human immune system and chronic diseases like hypertension, heart disease, chronic pulmonary disease and diabetes were related to consumption of contaminated drinking water and industrial waste. Similarly, Giusti, (2009) study stated that in developing countries, there is a direct and indirect impact of waste management on human health such as headache, skin rashes, heart diseases, eye problems, fever and respiratory problems. Kanchan et al. (2007), carried out a study at Ankleshwar GIDC, Bharuch, Gujarat and found that diseases like asthma, skin and eye irritation, respiratory, nausea, malaria, vomiting and body ache were more prominent in this region. In any region, untreated, hazardous industrial waste can be toxic and damaging to both environment and human health. Globally, regionally as well as locally industrial waste is of growing concern. Improper waste management in the vicinity of industrial regions is a great threat to the people who live near the dumping sites because of intoxicated environment (Guerra, 2002). Thus, waste management is considerably beneficial for economic development as well as environment.

1.2 Literature Review:

The issues related to groundwater quality had been investigated by different scholars in different ways. Adhikary et al. (2012) studied the groundwater quality in some peri-urban areas of Delhi and identified zones having suitable irrigation and drinking options. Gupta et al. (2005) discussed the origin of high fluoride in groundwater in the North Gujarat-Cambay region and identified certain fluoride rich sub-aquifer zones. Ghosh & Kanchan (2014) used geochemical and statistical approach to investigate the groundwater quality in the Bengal alluvial tract of India. Similarly, Goyal, Chaudhary, et al. (2010) worked on the groundwater quality zones for agricultural and domestic purpose of Kathial district of Haryana. Helena et al. (2000) studied the alluvial aquifer of the Pisuerga river, Spain and addressed that groundwater quality depends not only on aquifer lithology, groundwater velocity, quality of recharge waters and interactions with other types of water or aquifers but also on human activities which can alter the quality of it, either by polluting them or by modifying the hydrological cycle.

A few researchers focused on assessing the water quality of different areas. In the work of Basavaraddi et al. (2012), Water Quality Index (WQI) was used for assessing water quality of Tumkur district Karnataka. The study identified, the regions which have water suitable for drinking, domestic purpose and agricultural use. Similar study of Bhadja & Vaghela (2013) proposed Water Quality Index of reservoir water and assessed the impact of industries and human activities. The study revealed that, the pollution is relatively high in the reservoir water during summer. Similarly, Boyacioglu and Boyacioglu et al. (2010) monitored water quality data set to investigate seasonal variations of the Tahtali reservoir (Turkey) water quality. The paper concluded, that the surface water quality depends not only on natural processes but also on anthropogenic influences. The findings of the study showed, the seasonal variation of the water quality and revealed the anthropogenic impact on the Tahtali reservoir. Chang (2008) extensively worked on spatial analysis of water quality trends in the Han River basin, South Korea. The work revealed that the urban land cover was positively associated with increasing water pollution and included it as an important explanatory variable for the variation in all water quality parameters except pH. Another, investigation by Gadhia et al. (2013) on Tapi Estuary in Hazira industrial area (Gujarat) inferred that water quality of the estuary has been affected by the industrial and domestic effluents. In the study of Garaizi et al. (2011), the assessment of seasonal variation of chemical characteristics in surface water for the Chehelchay watershed (Iran), depicted significant seasonal variation in river water chemistry which was strongly affected by rock water interaction, hydrologic processes and anthropogenic activities.

Some works have determined the spatio-temporal pattern of different physico-chemical parameters in soil and water (surface and sub-surface). Seasonal pattern of heavy metal concentration was studied by Mondal et al. (2010) in the Tahgaon industrial area of Dhaka, Bangladesh while Ladwani et al. (2012) worked on lignite coal mine located at Surat (Gujarat, India). Ghosh & Kanchan (2011) attempted a study on spatio-temporal pattern of arsenic concentration in groundwater in Murshidabad district, West Bengal, India. Similarly, Yang et al. (2010) analysed the spatial and temporal pattern of water pollution in the Lake Dianchi (China) and concluded that the level of pollution of the lake gradually increased from south to north.

Statistical tools and techniques like Principal Component Analysis (PCA), Cluster Analysis (CA) and Discriminate Analysis (DA) were adopted by various researchers to observe the complex probable relationship between different elements and parameters. Kowalkowski et al. (2006) focused on water quality classification of the Brda River (Poland) by employing Cluster Analysis, Principal Component Analysis, Discriminant Analysis and Factor Analysis. Garizi, et al. (2011) used multivariate statistical techniques to analyse river water quality which was carried out by ANOVA, PCA and CA for the assessment of the seasonal pattern of pollution and its effects on the quality of river water. Similarly, Upadhyaya et al. (2014) employed PCA in the occurrence and distribution of selected heavy metals and boron in groundwater of the Gulf of Khambat, Gujarat, India.

Land use land cover analysis was studied by Anil et al. (2011), in the South West Godavari District, A. P. This study was conducted using remote sensing techniques and satellite data (Landsat, IRS-1D-LISS-III and SOI toposheets). Fallati et al. (2017) used change detection techniques to analyse environmental impact on fragile coral reef habitat using Worldview 1 and 2 satellite images. Misra & Balaji, (2015), made a study on, shoreline changes and land-use/land-cover along the south Gujarat coastline. This study analysed the decadal variations in historical shoreline modifications, using satellite images of Landsat TM, ETM and OLI.

Ebistu & Minale, (2013), attempted a study on, solid waste dumping site suitability analysis using Geographic Information System (GIS). In this study, potential landfill site identification was generated in GIS environment. Ghosh (2020)**,** worked on waste disposal issues in metropolises and small towns in state of West Bengal using AHP, Remote Sensing and GIS techniques.

1.3 Statement of Problem:

The indiscriminate disposal of solid, liquid and gaseous wastes from industries has an impact on water. Disposal of solid waste in open pits and depressions, discharge of untreated liquid waste through open drains and emissions of poisonous gases into the environment and agricultural practices are a few common features prevalent in the industrial regions and its vicinity. This problem of contamination is more acute in industrial regions and in their fringe areas where the concentration of physio-chemical elements can be more than the desirable and permissible limits.

Surat-Bharuch industrial region is geographically and economically favorable place with a pleasant climate and abundant natural resources. This area is rich in water sources because of being nearer to the coast and being a plain area dominated by perennial rivers. The region has efficient transportation system resulting in the coming up of many small and large-scale industries under the Gujarat Industrial Development Corporation (GIDC). Surat-Bharuch industrial region is a part of 'Golden Corridor' and also 'Delhi-Mumbai Industrial Corridor'. Various industries in this region produce different types of fertilizers, chemicals and petrochemicals, textiles etc. (Brief Industrial Profile of Bharuch District, 2012-13). Essar Group of Industries, Kribcho, Larsen and Turbo, Gujarat State Petroleum Corporation Ltd, Oil and Natural Gas Company, Hazira Complex of Reliance Industries, Gujarat Alkaline Industries ltd., National Thermal Power Corporation, Ankleshwar Gujarat Industrial Development Corporation, Jambusar Sterling Economic Zone etc. are some of the industries located in this region. Hazira, Surat, Panoli, Ankleshwar, Dahej and Bharuch industrial zones have large number of chemical industries, which discharge effluents affecting the surface water bodies, sub-surface water and the estuarine belt of Narmada and Tapi, Dhadhar, Viswamitr and Surya rivers [District Human Development Report Surat (2016) and Bharuch (2015) Districts].

Moreover, NH 8 traverses through the region which connects Delhi-Mumbai. Surat-Bharuch industrial region lies on the route of Express Way developed by National Highway Authority of India (NHAI). The region is a part of western railway zone and is well connected by eastern, western, northern and southern India (DIP Survey Report, Bharuch & Surat District, 2016-17).

Hence, the present study would be confined on the west of NH 8 along the Gulf of Cambay covering the districts of Surat and Bharuch which is an important industrial region of the state as well as of the country.

1.4 Objectiv:

The objectives of the present study -

1. Determine the spatio-temporal pattern of water quality.
2. Analyse the land use and land cover and identify the waste disposal sites.
3. Identify the industrial land use intensity pattern.

1.5 Hypothesis:

1. There is no significant seasonal variation in the physicochemical parameters of surface and sub-surface water.
2. There is significant seasonal variation in the physicochemical parameters of the surface and sub-surface water.

1.6 Database and Methodology

1.6.1 Water Sample:

To assess the water quality, 5 km^2 area grid for the entire region was prepared. From each grid, 1 Surface and 1 Sub-surface water sample was collected. Water samples were taken in six cycles (Surface and Sub-surface water samples) were collected in the season of post–monsoon (October-November) 2015, pre-monsoon (May-June) 2016, monsoon (September-October) 2016, post-monsoon (December-January) 2016-17, pre-monsoon (May-June) 2017 and monsoon (September-October) 2017 (Table 1). It approximately covered 4200 km (excluding the saltpan and inaccessible areas) area of mainland adjoining Gulf of Cambay, Gujarat, covering the districts of Bharuch and Surat (Fig. 1a, 1b, 1c).

Table 1.1. Numbers of Collected Samples (Surface and Sub-surface)

Season	**Number of Samples**		
	Surface	**Sub-surface**	**Tota l**
Post-monsoon (October-November) 2015	182	152	334
Pre-monsoon (May- June) 2016	152	155	307
Monsoon (September-October) 2016	177	152	329
Post-monsoon (December-January) 2016-2017	161	147	308
Pre-monsoon (May- June) 2017	131	132	263
Monsoon (September-October) 2017	159	130	289
Total	**962**	**868**	**1830**

Source- Collected

Total 1830 samples (Surface + Sub-surface) were collected, of which 962 were surface water samples, 868 sub-surface water samples.

Fig. 1.1 Water Sample Collection and Analysis

1.6.2 Tools and Technique

All the sampling locations and waste disposal sites were marked by Hand Held GPS (Garmin GPSMAP 78S). For, water sample sites, stratified random sampling technique was applied. The water samples were collected in 250/500 ml capped polyethylene bottles and thereafter were acidified with hydrochloric acid for laboratory analysis. Till the chemical analysis could begin the samples were refrigerated in deep freezer at a temperature below freezing point.

1.6.3 Chemical Analysis:

All the samples were preserved with the methodology suggested by Integrated Coastal and Marine Area Management (ICMAM) in 'Coastal Water Quality Measurements Protocol for COMAPS Programme' (Document No. R 30). Standard procedure was followed (APHA, 1998). The sub-surface water samples were taken from bore, well and hand pump and surface from ponds, river and lakes. Parameters like pH and TDS were determined on field by portable instrument (Hanna make, HI 98129). Esico Flame-Photometer (Model-1385) was used for the determination of concentration of chemical parameters like calcium and sodium (Fig. 1.2). Hanna make Ion Selective Electrodes was used for the detection of fluoride (HI4110). All laboratory work was done in the Department of Geography, Faculty of Science, The M.S. University of Baroda (Table 2).

For chemical analysis, Analytical Reagent grade or Lab Reagent grade (Merk, SDFCL, Sulab, Loban, National Chemicals) chemicals were used. All the glasswares were of Durasil, Borosil and Borosilicate make and were thoroughly sterilized by Hydrochloric acid, rinsed with distilled water and dried before analysis.

The data were tabulated, analysed and finally graphs were prepared in Microsoft Origins 9.2, Excel, ArcGIS 10.2 and SPSS V.22 software was used for the preparation of maps. Using Mapsource software, the sample location in GPS was transferred to the computer.

Table 1.2. Indian Standards and WHO's Standards for Physical and Chemical Parameters

S.No	Name of Parameters	Recommended Agency	Desirable Limit	Permissible Standards
1	pH	BIS	6.5-8.5	No Relaxation
2	TDS (mg/l)	BIS	500	1000
3	Calcium (mg/l)	BIS	75	200
4	Sodium (mg/l)	WHO	-	200
5	Fluoride (mg/l)	BIS	1	1.5

Source- https://www.bis.gov.in and www.who.int/

1.6.4 Identification of Waste Disposal Sites:

Industrial waste disposal (IWDS) sites were identified through satellite imagery (Google earth image and satellite image IRS-P6, sensor-L4 MN, Date of pass 31st March, 2016) after that latitude and longitude of the marked IWDS were noted and subsequently it was verified through field visit with the help of map and hand-held GPS.

1.6.5 Secondary Data:

Additionally, secondary information was gathered from the Smt. Hansa Mehta Library at the Maharaja Sayajirao University of Baroda in Gujarat. Online journals were referred through Google Scholar (http://scholar.google.co.in/schhp?hl=en), Journal of Hydrology (www.journals.elsevier.com), Science Direct (www.sciencedirect.com), Springer Online (www.springer.com), Wiley Online Library (onlinelibrary.wiley.com), Oxford Journals (www.oxfordjournals.org), American Chemical Society Publications (http://pubs.acs.org/), Directories Open Access Journals (www.doaj.org), Taylor and

Francis (www.tandf.co.uk/journals), District Census Handbook (https://censusindia.gov.in › nada › catalog), Brief Industrial Profile District Bharuch, Government Of Gujarat (https://bharuch.nic.in › document › brief-industrial-pro). All of the aforementioned websites were viewed and papers were downloaded from The Maharaja Sayajirao University of Baroda's portal via INFLIBNET. Toposheet (Toposheet No 46 F/3, 46 B/12, 46 B/16, 46 C/12, 46 F/04 with R.F. 1:50000) were taken from the Department of Geography, Faculty of Science, The Maharaja Sayajirao University of Baroda. Rainfall data for various years were acquired from the Indian Metrological Department's website (http://www.imd.gov.in/pages/city weather main.php). Geological Survey of India (https://bhukosh.gsi.gov.in › Bhukosh › Public), Central Ground Water Board, Ministry of Jal Shakti ...(http://cgwb.gov.in). Satellite images (IRS LISS III and LISS IV) were purchased from NRSC Web Site (https://www.nrsc.gov.in). Google Earth images were also used during various phases of the research: Explore Google Earth (https://earth.google.com).

Fig.1.2 Esico Flame Photometer and Ion-Selective Probe

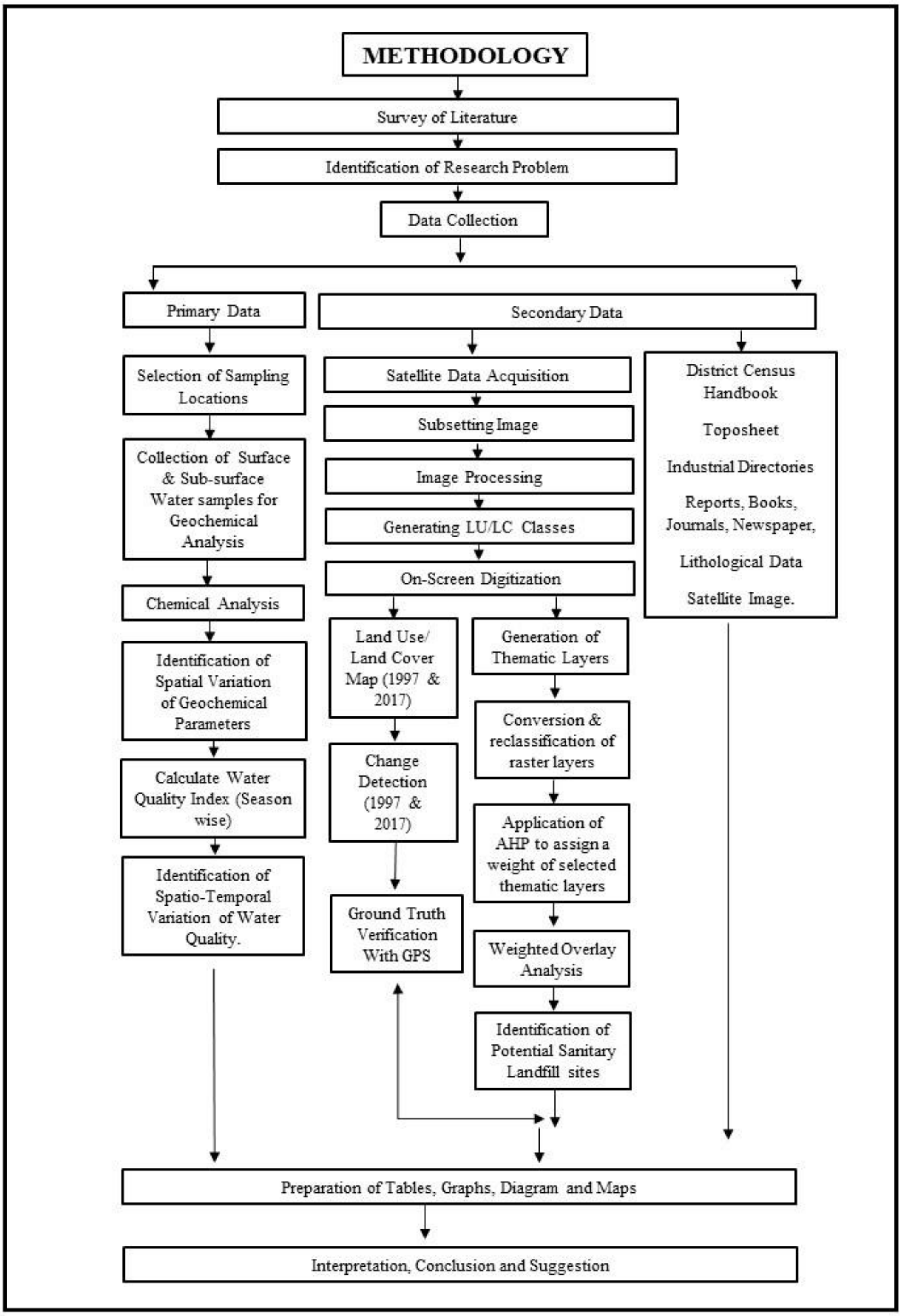

Fig. 1.3 Flow Diagram of Methodology

Fig.1.4. Sample Analysis, Department of Geography, Faculty of Science, The M.S. University of Baroda

Resume:

In this first chapter, the primary focus was to introduce the research problem, review the literature, define the objectives, hypothesis, methodology and database. The next chapter would focus on the study area.

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