Chapter – I

Introduction

The blue planet- earth is vulnerable to environmental concerns such as climate change, global warming, air pollution, urban sprawl, acid rain, water pollution, waste disposal and ozone depletion. The major concern among all the aforesaid was water. The history of human civilization reveals that water supply and civilization ate almost synonymous. Several cities and civilizations have disappeared due to water shortage originating from climatic changes [1].

About 97% of the earth's water is in ocean which is unfit for human consumption. Of the remaining 3%, 2% is locked in the polar ice caps and only 1% is available as fresh water in rivers, lakes, streams, reservoirs and groundwater. The majority of water used for thermoelectric power, public supply, irrigation, mining, and industrial purposes came from surface-water sources. The distribution of surface water is as follows fresh water 3%; saline water 97%; in the available fresh water 30.1% falls in groundwater and the remaining 68.7% in ice caps and glaciers [1].

Ground water and surface water are the mostly used sources of water by mankind. Ground water contains dissolved minerals from the soil layers. The ground and surface waters are being contaminated by seepage, sewage, agricultural runoff etc [1].

India has about 16 percent of the global population as compared to only 4 percent of its water resources. With a population of over 1,200 million, the per capita water availability is around 12,1470cu m/ person/ year reported by NIH, 2010. India is the largest consumer of groundwater in the world. A report from United Nations showed that India was the highest drawer of ground water between 2000 and 2010. Most of the fresh water sources available are utilized for agricultural purposes in India.

World Health Organization has identified various facts which underpin water scarcity and its impact on our daily lives as well as the economy and development across the world. It has given ten facts to resolve the problem of water scarcity. WHO has estimated that water consumption will have to be cut by 50% by 2025 if nations fail to address imbalances in global water supply and demand [1].

Alcmaeon of Croton was the first Greek doctor to state that the quality of water may influence the health of people. Hippocratic treatise *Airs, Waters, Places* (around 400 B.C.) deals with the different sources, qualities and health effects of water at length [2].

The main threat being faced by the present day world is water pollution. It is the contamination of water bodies through direct or indirect discharge of pollutants into. It is suggested that water pollution is the leading worldwide cause of deaths and diseases and that it accounts for the death of more than 14,000 people per day [3]. According to CHNRI, an estimated 580 people in India die of water pollution and related illness per day. In addition to the acute problems of water pollution in developing countries, developed countries also continue to struggle with pollution problems. The situation is not limited to developing countries like India. According to USEPA, in the United States, 45 percent of assessed stream miles, 47% of assessed lake acres, and 32 percent of assessed bays and estuarine square miles were classified as polluted. Causes for the problem are elevated temperatures, pathogens, contamination by industrial effluents, agricultural runoff and household seepage [4].

Globally, scientists and health advisors are concerned with the health issues which are due to the consumption of unsafe water. Globally it was found that most of the surface waters, groundwater and reservoir water are being contaminated and made unsuitable for human consumption. In some areas throughout the world the concentration of toxic metals, organic pollutants and other minor pollutants is alarming and this made the scientists all over the world to perform physico chemical and biological analysis of different sources of water available for assessing its quality and suitability for human consumption. Eutrophication and the associated ecological effects result in a general decline in overall water quality, restricting its use for general and drinking purposes [5-6].Urbanization, industrialization, human activities, anthropogenic activities, seepage and sewage contamination are some of the reasons for poor quality of water throughout the world.

Water Quality Index (WQI) is easily comprehended and appreciated by common citizens and policy makers in assessing the quality of water. It also helps in meeting regulations and/or making personal lifestyle adaptations for the benefit of the environment. A detailed review on literature on water quality assessment, physico chemical characterization for ground water and surface water follows hereafter.

1.1 Literature review

The concept of Water Quality Index was adopted by various organizations across the world to assess the quality of the available water resources. [6-10]. Globally researchers and scientists carried out their research and presented the experimental results in articles [11-19].

The Deficiencies in nutrients, farm effluents, pesticides and bacterial contamination of soil and water are some of the main concerns regarding water quality. Hooda et al presented a review on water quality concerns in UK on the issues mentioned. [20].

Ground water quality in Nigerain Urban areas was reviewed by Ocheri [21]. He found that Nigerian urban groundwater quality is influenced by geology, geochemistry of the environment, urbanization, industrialization landfill, leachates, heavy metals and bacterial pollution.

An over view of different water quality models helpful in assessing the quality of the water werepresented in a review by Tsakiris [22]. A review on relative vulnerability of groundwater pollution was presented by Barber [23].

The impacts of pit latrins on groundwater quality were reviewed by Jay P. Graham [24]. A review of groundwater status, challenges and research needs in Khatmandu, Nepal was presented by Pradhang [25]. Wen-Qing Lu et.al presented a detailed paper on water pollution and its health impacts in China [26]. Gorde elaborately presented a review on water quality assessment parameters in his research article [27].

No. of reviews are available in literature [28-49] on physico chemical assessment, metal ion analysis of water samples in various regions of globe, WQI of different regions. These are summarized in table 1.1.1

S.No	Title of the research article/ thesis	Authors	Reference No
1	Analysis of ground water – A review	Devendra Dohare Shriram Deshpandey Atulkotiya	28
2	GIS based drastic method for ground water vulnerability assessment- A review	S M Shirazi et al	29
3	Water quality indices Important tools for water quality assessment- A review	Bhattacharya Tanushree Chakaraborthy Sukalayn	30
4	Monitoring for ground water quality assessment- current constraints and strategies	P J Chitton S S D Foster	31
5	Ground water quality assessment – Assessment of Anekaltaluk, Bengalore urban districts, India	K C Prakash R K Somasekhar	32
6	Assessment of ground water quality and its suitability for drinking and agricultural uses in the Oshnavieh area	Nosrat Aghazadeh Asghar Asgharmogaddam	33
7	Ground water chemistry and quality of Nigeria A status review	A Edet et al.,	34
8	Evaluation models for assessing ground water vulnerability to pollution in Nigeria	Uman Sheikh Abdullahi	35
9	Assessing ground water quality using GIS	Insaf Babiker	36
10	Changing paradigms in ground water ecology- from the living fossils to the new ground water ecology	Colin S Reynolds	37
11	India ground water governance – case study	Hector Garduno et al.,	38

12	Ground water availability and use in sub Saharan Africa- A review	Paul Pavelic et al.,	39
13	Ground water peer review	National Ground water association	40
14	A review of regional ground water flood modeling	Yangixao Zhou	41
15	A review of ground water quality issue in Jharkhand due to fluoride	Neeta Kumari et al	42
16	A review of surface water quality models	Qinggai Wang et al.,	43
17	A review of the potential impacts of climate change surface water quality	P G Whitehead et al.,	44
18	A review of selected inorganic surface water quality monitoring practices	Arthur J Horowith	45
19	Review of water pollution control in china	Tingyao Gao et al.,	46
20	Analysis of drinking water of different places_ A review	S P Bhalme	47
21	The challenge of documenting water quality benefits of conversation practices: a review of USDA	M D Torner M A loke	48
22	Water quality standards Review	IDNR	49

Table.1.1.1 Summary of the Review articles

Physicochemical characterization of groundwater samples of Veppanthattai taluk in Perambur district of Tamilnadu was reported by Lilly Florence et.al [50]. They reported that out of the twelve samples analyzed, six were of good quality and the remaining is not. It was also found that the water samples of some villages have high hardness and fluoride concentration. They suggested that the water can be used for drinking purpose after treatment.

Vijay [51] in his research reported the hydro chemical faces and physico chemical characterization of thermal spring water of Unkeshwar, Maharashtra. It was reported that the water samples analyzed fell into Ca-Mg domain.

Physicochemical analysis of groundwater in Bidar city and surrounding industrial area was discussed by Shivasharanappa et.al [52]. Their analysis revealed that the water analyzed was good in quality.

Variation in physico Chemical characteristics in the groundwater of Tirunelveli District of Tamil Nadu, India was presented by Ganapathi Subramanian et.al [53]. From the analysis it was found that the abundance of major ions in the groundwater was in the order of Na Ca> Mg >Na+K>Cl> SO4> TDS> TH. It was concluded that the water is fit for domestic and agricultural purposes with minor exceptions irrespective of seasons.

A research article aimed at the physico chemical Characterization of ground water in Anand district of Gujarat, India was reported by Bhattacharya et.al [54]. It was concluded that the water samples analyzed were found to be good in their quality and suitable for drinking, irrigation and industrial purpose.

Anita Joshi and Gita Seth [55] aimed at the physico chemical characterization of groundwater of Sambhar Lake City and its adjoining area in Jaipur District of Rajasthan, India. Most of the physico chemical parameters analyzed were found to have concentration levels beyond the prescribed standard limits. The author’s suggestedthat the water must be treated before use.

Ramakrishnaaiah et al [56] reported the quality of groundwater of Tumkur taluk in Karnataka.

Groundwater quality assessment of Nagpur region was presented by Rajasekhar et al [57]. Assessment of groundwater quality in Bhavnagar region of Gujarat was presented by Deepthi et.al [58]. All the samples of groundwater analyzed were found to have concentrations within limits. And the water was found to be suitable for drinking.

Surface water (Lakes) quality assessment in Nagpur City, India based on Water Quality Index (WQI) was presented by Puri et.al [59]. From the WQI data it was concluded by the authors that the water is graded poor in quality during summer, medium in winter and good in rainy season.

Assessment of groundwaterquality in and around Gobichettipalayam town Erode District of Tamilnadu is presented by Palanisamy et.al [60]. It was reported that the water samples analyzed were suitable for human consumption.

Assessment of groundwater quality in a typical rural settlement in Southwest Nigeria was reported by Adekunle1et al [61]. The water samples analyzed were found to have concentrations of various parameters with in standard limits.From the reports, it was inferred that the water is fit for drinking purpose. Regular monitoring of water quality was suggested by the authors

Groundwater quality assessment on Anekal Taluk of Bangalore Urban district, India, was reported by Prakash and Somashekar [62]. It was reported that the water is fit for human consumption.

Rizwan and Gurdeep [63] reported Assessment of groundwater quality status using Water Quality Index Method in Orissa, India. The water quality index values of the villages were in the range 14-57 in summer while 19-67 in post monsoon season and concluded that the water is poor in its quality and unfit for drinking.

Assessment of groundwater quality using Water Quality Index method was reported by Srinivas Rao and Nageswararao [64]. The quality of the water samples analyzed was found to be poor. Salt water intrusion was also reported. The water analyzed was unsuitable for human consumption.

Assessment of groundwaterquality using Water Quality Index (WQI) method was reported by Cristina Roşu et.al [65]. The water samples analyzed were found to be unsuitable for human consumption due to the presence of higher mineral concentrations.

In their research article, Jothivenkatachalam et.al [66] presented correlation analysis for various physical and chemical parameters in drinking water in and around Perur block of Coimbatore District of Tamil Nadu, India

Heydar et.al [67] in their research paper discussed correlation and regression analysis of drinking water in Kashan city of Iran. Regression analysis and correlation matrix data revealed that the physico chemical parameters analyzed possess a linear correlation.

Anita and Pooja Devi [68] presented applications of correlation and regression analysis in assessing lentic water quality at Brahmsarovar Kurukshetra, India. From the regression analysis and correlation matrix reports it was concluded by the authors that these data are significant in predicting water quality of the area under investigation.

Manish Kumar and Yashbir [69] interpreted Water Quality Parameters in the villages of Sanganer Tehsil using multivariate statistical analysis. Correlation matrix data was found to be helpful in monitoring the water quality of surface as well as ground water.

Ganesh Ram Namdev et.al [70] studied the effect of chemical fertilizers on the water quality in Kalistoe reservoir of Madhya Pradesh, India. In their study the authors presented physico chemical characterization of the reservoir water. They found that the reservoir water is free from contamination.

A case study on the highly polluted Lahrpur reservoir Bhopal, Madhya Pradesh was presented by Pandey et.al [71]. The authors concluded that the water of the reservoirwas highly polluted by municipal sewage contamination. The water is rated as unfit for irrigation purpose.

Sangpal et.al [72] in their research presented a complete physico-chemical characterization for the determination of pollution potential of the Ujjani reservoir. It was inferred thatdue to industrialization and urbanization, the water of the reservoir was deteriorated.

In their research paper Garg et al [73] presented a study of water quality and consumption management of Ramsagar reservoir of Datiya, Madhya Pradesh. In their study they concluded that the water of the reservoir was good in quality. All the nutrients were present in sufficient quantities for the growth of aquatic life. They also concluded that the water of the reservoir is mesotropic in nature.

In their research article, Saritha et.al [74] presented characterization of groundwater in different activity regions of an urban settlement. Their study was aimed at the assessment of groundwater quality in some selected areas of Visakhapatnam, Andhra Pradesh. It was concluded that the water samples analyzed were found to have higher concentration of parameters than the prescribed standard values. Hence, it was concluded that the water is unsuitable for drinking purpose.

Rajasekhar et.al [75] presented the determination of quality of the water from the Nizamsagar reservoir located in Nizambad district of Andhra Pradesh, now in Telangana. In the study they inferred that the water of the Nizamsagaar reservoir is suitable for irrigation, agricultural drinking as well as the production of hydroelectricity.

Okoyeh [76] presented a detailed report on physico chemical characterization of ground water in Kotur region of Hyderabad. An assessment of ground water quality and its impact on the residents of Chittor district, Andhra Pradesh is presented by Balaji et.al [77]. Subba Rao et.al [78] depicted the assessment of drinking water quality in Srikurmaam of Srikakulam district of Andhra Pradesh. Sundar Kumar et.al [79] presented the assessment of water quality of ground water using water quality index method in Bopulapadu mandal of Krishna district of Andhra Pradesh.

Ground water quality analysis using water quality index method was done by Sudhakar [80] for the ground water samples of Bapatla mandal, Guntur District of Andhra Pradesh.

Assessment of water quality of Godavari River at Nanded and Rajahmundry was presented by Srinivasa Rao [81]. Hanuman Redy [82] presented in detail about the heavy metal analysis in surface and ground water of Tirupathi of Andhra Pradesh. Venakat Subbaraju [83] analyzed ground water samples from coastal areas of Nellore district of Andhra Pradesh. Ravi Shankar and Prasada Rao [84] presented a research on the analysis of heavy metals in the water samples of industrial ground water around Vijayawada of Andhra Pradesh.

Hariharan et.al [85] presented a report on heavy metals analysis in the vicinity of Sriramnagar of Vizianagaram district, Andhra Pradesh.

In literature [86-157], it was presented the observations on water quality assessment data of various rivers, estuaries and ground water of chosen sites. The investigations of different authors are summarized in table 1.1.2.

The present study of the author is aimed at the physico chemical characterization, water quality assessment based on WQI and heavy metal analysis of ground water and reservoir water in the vicinity of Champavathi River.

S.No	Title of the article	Name of the authors	Ref No
1	Ground water Quality assessment in Yenagoa, Environs Bayelsa State Nigeria	Gordon T Amangabara	86
2	Physico chemical analysis of ground water samples of Bichi, local government area of Kano state Nigeria	Emmanuel Bernard Murudeen Ayeni	87
3	Physico chemical characteristics of ground water in old port Harcourt township, Eastern Niger Delta	F I Fashola H O Nwankwola A C Tse	88
4	Physico chemical studies of water from selected boreholes in Umuahia North local Government area, in Abia State, Nigeria	N I Onwughara et al.,	89
5	Physico chemical characteristics of bore well water quality in Nagpur region	Dattatraya Bharti et al.,	90
6	Assessment of Physico chemical quality of ground water sources in ga east Municipality of Ghana	Richard Amfo Otut et al.,	91
7	Investigation into the physico chemical properties and hydro chemical processes of ground water from commercial bore wells in Yenagoa, Bayelsa, Nigeria	Agbalagba O E	92
8	Physico chemical characteristics of ground water of Manachanallur Block Trichy	M Ramesh et al.,	93
9	Physico chemical characteristics of ground water of various villages around Raisar	Sushma Jain Monika Agarwal	94
10	Water analysis of four main reservoirs in Northern Jordan	Safwan M obeidat	95
12	Water quality index and correlation study for the assessment of water quality and its parameters of Yercaudtaluk, Salem district, India	Lilly Florence et al	96
13	determination of concentration of heavy metlas in fish, water and sediments of Avsar dam in Turkey	M Ozturk et al	97
14	concentration levels of heavy metals in water and sediments of lake Victoria, east Africa	D O Ogoy	98
15	Studies on metals of Siddheshwar reservoir, Maharashtra	Shaik Praveen R et al	99
16	Heavy metal analysis of the ground water samples collected from Bilaspur town and surrounding rural areas of Madhya Pradesh	K B L Srivastava	100

18	Study on the determination of some selected heavy metals in the surface waters of the Ikpoba reservoir in Nigeria	O M Wangboje	101
19	Determination of heavy metals in the largest fresh water reservoir in Thailand	Tinapan Netpae	102
22	Analysis of seasonal water pollution based on rainfall feature at Anyang river basin Korea	Han J G et al	103
23	Water quality evaluation trends analysis in selected watersheds of the Atlantic region of Canada	Khan F et al	104
24	The water quality of the VrgorskaMatica river	Nives S G	105
25	Hydrological influences on the water quality trends in Tamoraparani basin south India	Ravichandran S	106
26	A generalized water quality index for Taiwan	Liou Shiow Mey et al	107
27	Arsenic and heavy metal pollution of soil, water and sediments in a semi arid climate mining area in Mexico	Razo I et al	108
28	Ground water quality and contamination index mapping in Changchun city , china	Hamadoun B et al	109
29	Estimation of heavy metals (Cu, Zn, Pb) input into Pannat Bay	Mikulic n et al	110
30	Toxic aluminum and heavy metals in ground water of middle Russia: health risk assessment	Momot O et al	111
32	Assessment of ground water quality for physico chemical, heavy metal, bacteriological contamination in and around Raigarh city	Shrivastava B K et al	112
33	Evaluation of water quality in the Chillan River (central Chile) using physico chemical parameters and a modified water quality index	Debels p et al	113
34	The quality of potable water types in Jordan	Bataresh M I et al	114
35	Application of water quality indices and Do as indicator for river water classification and urban impact assessment	Kannel P R et al	115
36	Investigation of heavy metal contamination in the lower Sakrya river water and sediments	Dundar M S	116
37	Surface water quality assessment by environmetric methods	Boyacioglu H Boyacioglu H	117
38	Monitoring water quality and quantity of National watersheds in Turkey	Odemis B Evrendilek F	118

39	Inorganic parameters as water quality indicators in acidic ground water in a tropical region- Brasilia	Boaventura G R et al	119
40	Arsenic in the environment: Biology and Chemistry	Bhattacharya P et al	120
41	Toxic trace element pollution in ground water around Patancheru and Bollaram industrial areas Andhra Pradesh India A graphical approach	Shivkumar K et al	121
42	Evaluation of ground water quality in Dakhla Oasis (Egyptian western desert)	Soltan M E et al	122
43	Assessment of water quality of KHNOP reservoir in Chatrpur, Madhya Pradesh	Jain P K	123
44	Trace metals in and around an industrial belt	Sawant C P et al	124
45	Monitoring of ganga water and sediments vis-avis tannery pollution at Kanpur, India- A case study.	Khwaja A R et al	125
46	Acidification of surface water in central India	Aggarwal S G et al	126
47	Evaluation of surface water quality characteristics by using multivariate statistical techniques: A case study of the Euphrates river basin , Turkey	Iscen C F et al	127
48	Spatio temporal variations in water quality of NullahAik tributary of the river channel, Pakistan	Qadir A et al	128
49	Evaluation of water quality index for drinking purpose for river Nethravathi, Manglore, South India	Avvannavar S M et al	129
50	Heavy metal pollution and Eutrophication in the lower Salado river Basin (Argentina)	Gagneten M et al	130
51	Ground water pollution of the quaternary aquifer in Northern United Arab Emirates	Al-Hogaraty E et al	131
52	Monitoring heavy metal pollution of ground water in Phreatic aquifer in Mersi, Turkey	Demirel Z et al	132
53	Water quality changes in Chili lake, Pehang, Wet Malaysia	Othman Md S et al	133
54	Statistical source identification of metals in ground water exposed to industrial contamination	Tariq S et al	134
55	Heavy metal contents and the water quality of Karasu creek in Nigade, turkey	Yalcin M G et al	135
56	Factor analysis and linear regression model of metal speciation and physico-chemical characters of ground water samples	Kumaresan M Riyazuddin P	136
57	Evaluation of river water quality variations using multivariate statistical technique	Andrea mariavoic Domagoj Ruzdjak	137

58	Ground water quality and hydrochemical properties of Al-Ula region, Saudi Arabia	Naji-Toumi et al	138
59	An assessment of selected hydrochemical parameters trend of the Irakdong river water in South Korea	S Y Chung et al	139
60	Evaluation of ground water suitability for irrigation in the Skhirat region Northwest of Morocco	Abddrjid Zouari	140
61	Assessment of water quality parameters using multivariate analysis for Klang river basin	Ibrahim mohammad	141
62	Multivariate analysis of drinking water quality parameters in Bhopal, India	Charu Parasharam et al	142
63	A comparative assessment of the physico chemical and microbial trends in Njaba river, Niger river basin Southwestern Nigeria	Cosmas Ahamefula et al	143
64	Analysis of sheep production systems: North coastal zone of Andhra Pradesh	K Anandrao et al	144
65	Phytosociological attributes of weed flora in major crops of North coastal Andhra Pradesh India	Prayaga Murthy Pragada	145
66	PhD thesis- Determination of water quality of some rural areas of Guntur district, Andhra Pradesh	Ch Subba Rao	146
67	PhD thesis- Assessment of ground water quality and its suitability for drinking and irrigation purposes of Prakasam district Andhra Pradesh, India	Ch Maruthi Devi	147
68	PhD thesis- Studies on the physico chemical and heavy metal quality of selected ground water samples in Visakhapatnam city, Andhra Pradesh, India.	Yaduvams Madhusudhan E	148
69	PhD thesis- Microbiological and physico chemical analyses of drinking water sources in Rajahmundry east Godavari district, Andhra Pradesh, India	Soni Sarika Mellimi	149
70	PhD thesis- A study on water quality of some selected water samples in and around Gajuwaka industrial area, Visakhapatnam city , Andhra Pradesh, India	SyamSree K	150
71	PhD thesis- A physico chemical and bacteriological study of ground water quality in Visakhapatnam city, Andhra Pradesh, India.	Sasikala V	151

72	PhD thesis- A study of physico chemical and bacteriological characteristics of drinking water from different sources of Bhimavaram Andhra Pradesh, India.	Jhansilakshmi Kondaveeti	152
73	PhD thesis- Water analysis of Bilaspur city with reference to pollution due to heavy metal population & industrialization	Verma S	153
74	PhD thesis- Water quality studies in selected areas in Malabar region Kerala state	UshaKumari S	154
75	PhD thesis- Hydrogeology, Morphometry and Remote Sensing Studies on Champavathi River basin, Vizianagaram District, A.P.	P Jagadesswara Rao	155
76	PhD thesis- Studies on distribution of heterotrophic bacteria in champavathi estuary (Vizianagaram, east coast of India) and their sensitivity to some plant extracts with special emphasis on molecular characterization of vibrio harveyi	M Sridevi	156
77	PhD thesis- Some aspects of the quality of water in and around Rourkela	Prakash Chandra Mishra	157
78	http://en.wikipedia.org/wiki/Vizianagaram_district		158
79	http://www.ap.gov.in/AP%20State%20Statistical%20Abstract%20May%202014/6%20AP%20Irrigation.pdf		159
80	http://dcmsme.gov.in/dips/vizianagaram%20profile.pdf		160
81	http://irrigation.cgg.gov.in/dp/VizayanagaramDistrictProfile.jsp		161
82	http://en.wikipedia.org/wiki/Andra,_Vizianagaram		162
83	http://www.worldlibrary.in/articles/River_Champavathi		163
84	http://www.indiamapped.com/rivers-in-india/champavathi-river/		164
85	http://en.wikipedia.org/wiki/Champavathi_River		165
86	http://www.indiamapped.com/rivers-in-india/champavathi-river/		166

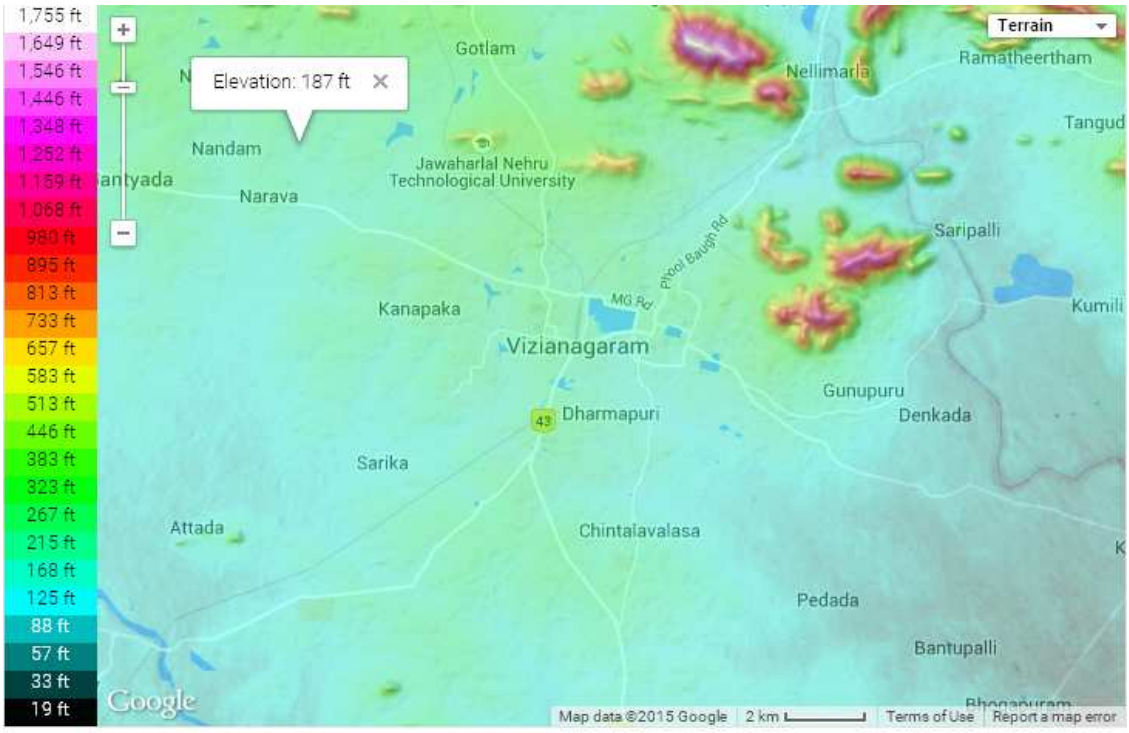
Table. 1.1.2 Literature review on the problem chosen

1.2 STUDY AREA

Andhra Pradesh, abbreviated A.P., is one among the 29 states of India situated on the southeastern coast. Andhra Pradesh is bordered by Telangana, Chhattisgarh and Orissa in the north, the Bay of Bengal in the east, Tamil Nadu to the south and Karnataka to the west [158].

Topography of the study area

Vizianagarm is the north coastal district of Andhra Pradesh. The district was formed on 1st June 1979 as 23rd district in the state of Andhra Pradesh by carving portions from Srikakulam and Visakhaptanm districts. It is bounded on the East by Srikakulam district, on the West and South by Visakhapatnam district, on the South-East by Bay of Bengal and North-West by Orissa State [158, 159].



HILLS

The district was divided into two distinct natural physical divisions' plain and hilly regions. The Agency tract mostly consists of the hilly regions covered by the Eastern Ghats which run parallel to the Coast from the North-East to the South-West. The average height of these hills is over 914 metres although there are several peaks of even 1219 metres high. The highest peak is the Shankaram in Srugavarapukota mandal which is over 1615 metres [160].

RIVERS

The district was drained by the rivers Nagavali, Gosthani, Suvarnamukhi, Champavathi, Vegavathi and Gomukhi. These rivers pass through plain and hilly regions. *Champavathi* River originates in the Eastern Ghats and flows through Saluru. It finally mixes into Bay of Bengal at Konada village in Pusapatiregamandal of the district [160].

FLORA

The district receives rains from both the monsoons and the climate is tropical. The floristic diversity is noticed in the quality and density of forests which range from 6 metres in poorer areas to over 20 metres in better areas. Forests vary in density from vast extents of full density seen in the inner remote areas to sparse open forests due to biotic abuses around habitation [160].

FAUNA

Fauna in the district is fairly high in the interior hill regions, but it is heavily threatened with extinction. The principal animals and birds found from along the sea-coast to the high plateau are Yellow Bat, Sloth Bear, Wild buffaloes, Fox, Hare Hyena, Jackal, Mongoose and birds of blue rock Pigeon, House crow, House sparrow, Common Myna etc [160].

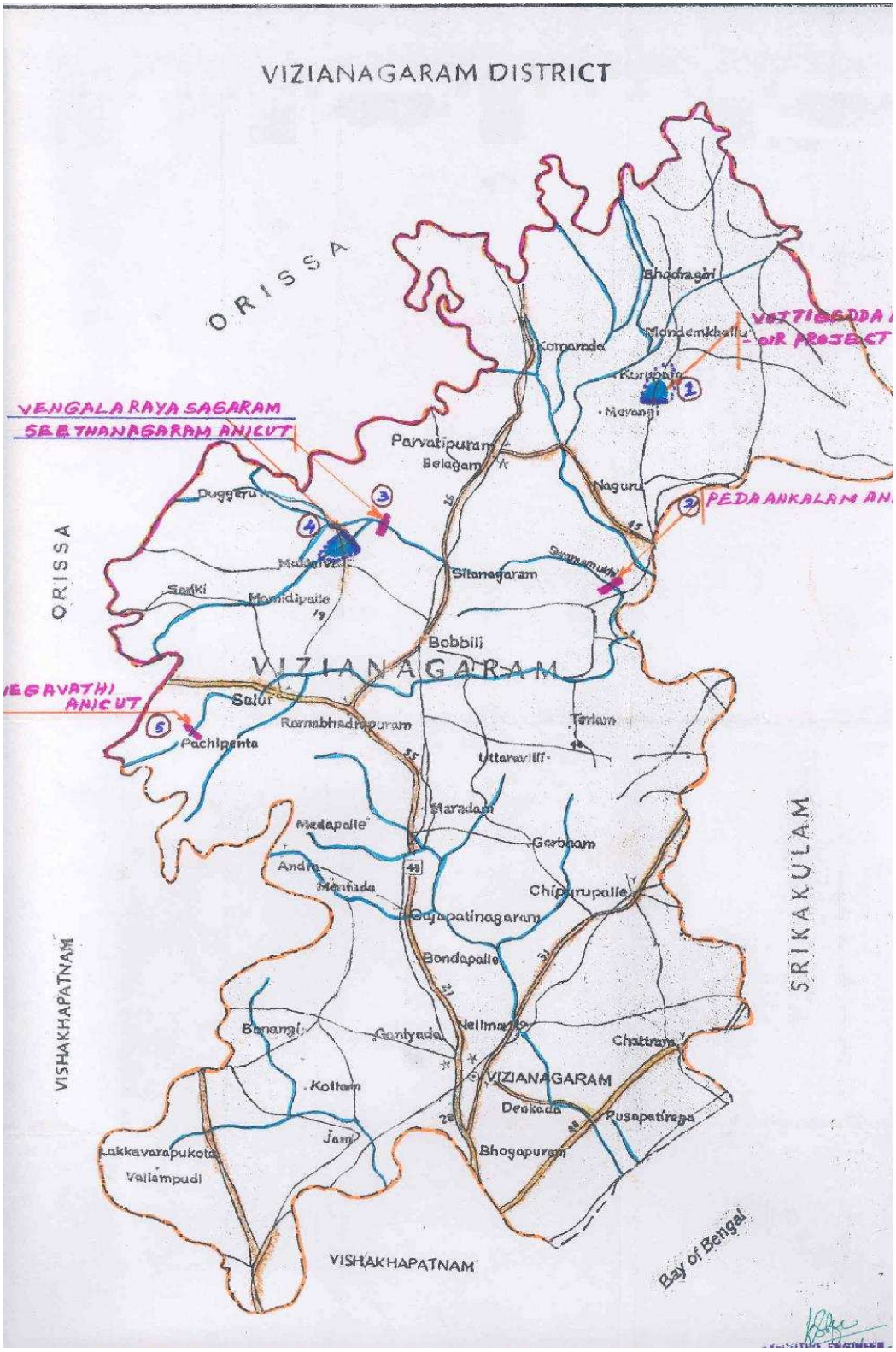


Fig. 1.2.1 Vizianagaram district map- study area

CLIMATE

Climate of the District was characterized by high humidity all the year round with oppressive summer and good seasonal rainfall. Summer season is from March to the middle of June. This is followed by the South-West monsoon season which lasts up to about the 2nd week of October. The period from Mid October to the end of November constitutes the post monsoon or retreating monsoon season. December to February is the season of generally fine weather. The maximum temperature will be recorded during May and the minimum temperature will be during December [160].

TEMPARATURE

In the interior low level area of the district, temperatures in summer are about 2 to 3 degrees higher than in the coastal region. In hilly tracks, the temperature in general may be lower than in the coastal region by about a couple of degrees or so, depending on elevation. From about the middle of February, the temperatures rise rapidly till May which is the hottest month with the mean daily maximum temperature at about 42^{o}C and the mean minimum at about 27^{o}C [160].

RAINFALL

Rainfall is being recorded at 34 rain gauge stations in the Mandal headquarters of the district. The annual rainfall for the district is 1131 mm. The district mostly gets rainfall during south west and north east monsoons. The normal rainfall during South-west monsoon months, June to September amounts to 71% of the annual rainfall and that during North East monsoon months of October to December constitutes 11 percent of the annual rainfall. June (380 mm), September (321 mm) are the heavy rainfall months in the year [160].

SOILS

Main soils in the District are red soils; Sandy Loams and Sandy Clay.These constitute 96% of the total area. The soils in the District are predominantly loamy with

medium fertility. There are mostly red loamy soils, as far as dry lands are concerned and clay loamy in case of wet lands. The soils at some places are as thick as 4 Meters. It is likely that the thick soil cover might represent alluvium along the valleys. Different types of rocks are in abundance in the district [160].

To ascertain the suitability of groundwater and surface water in the vicinity Champavathi river for human consumption physico chemical characterization, water quality index calculation and heavy metal analysis was performed.To do such, ten villages namely Andra, Mentada, Aaguru, Gajapathinagaram, Seetharampuram, Nellimarla, Saripalli, A.T Agraharam and Konada were selected for groundwater analysis. Andra village is very close to the originating place of the river and village Konada is in the vicinity of the estuarine point of the river. All the other villages are in between these two points. Across the river two reservoirs namely Andra reservoir and Denkada anicut were constructed for the purpose of irrigation.

The following table gives a complete data of the latitude- longitude along with the number of sampling stations chosen and the type of the sampling stations available.

Most of the villages under study were found to have only bore-wells. In totality sixty sampling stations were identified and selected for the collection of groundwater samples.

S.No	Name of the village	No. of sampling stations	Type of sampling stations	Latitude	Longitude
1	Andra	5	Bore wells	18.3500	83.2000
2	Mentada	5	Bore wells	18.3109	83.2592
3	Aaguru	5	Bore wells	18.3309	83.2929
4	Gajapathinagaram	5	Bore wells	18.2797	83.3333
5	Seetharampuram	5	Bore wells	18.3197	83.3733
6	Nellimarla	5	Bore wells	18.1642	83.4534
7	Saripalli	5	Bore wells	18.1313	83.4823
8	A T Agraharam	5	Bore wells	18.1153	83.5110
9	Nadiapalle	5	Bore wells	18.0411	83.5443
10	Konada	5	Bore wells	18.0174	83.5623

These villages were chosen based on the population strength and utility of both ground and surface water resources available.

The river Champavathi flows through the district and travels a distance of 120 km and mixes in Bay of Bengal at Konada.

Fig.1.2.2 Estuarine point of the river at Konada village

Most of the villages are utilizing bore well water for all domestic purposes including drinking purposes. **Andra** [161, 162]is a village and panchayat in Mentada Mandal, Vizianagaram district of Andhra Pradesh, India. It is located about 7 km from Mentada and about 34 km from Vizianagaram city. In the village Andra five sampling stations were identified and samples of water was collected for analysis.

Mentada is a village and Mandal in Vizianagaram district of Andhra Pradesh, India. Mentada is located at 18.3167°N 83.2333°E. It has an average elevation of 104 meters

(344 ft). In the village Mentada five sampling stations were identified and all of them are bore wells only. It was found that the bore wells were situated near seepage canals.

Aaguru is a village and panchayat in Mentadamandal of Vizianagaram district. Six sampling stations were chosen for the physico-chemical characterization water quality studies from the village. River Champavathi flows through the village Aaguru. During sample collection it was observed that most of the solid waste is dumped into the river at this site. All the sampling stations hosen were bore wells.

Gajapathinagaram is a Town and Mandal in Vizianagaram district in the state of Andhra Pradesh, India. It is located on National Highway 43 between Vizianagaram and Ramabhadrapuram. According to the Imperial Gazetteer, Gajapathinagaram Tahsil in Vizagapatam district had about 228 villages and covered an area of 333 square miles (860 km^2). River Champavathi flows through Gajapathinagaram. In the town of Gajapathinagaram four sampling stations were identified, are bore wells.

Seetharampuram is a village and panchayat in Gajapathinagaram mandal of Vizianagaram district. Five sampling stations were chosen from the village Seetharampuram for the study.

Nellimarla is a town and mandal located in Vizianagaram district. Nellimarla is located on the banks of Champavathi River at 18.1667°N 83.4333°E. It has an average elevation of 190 meters (626 ft). It was found that, in each of the street more than ten bore wells were identified. And hence from each street of the town five sampling stations were selected and performed all analytical procedures.

A T Agraharam is a village and panchayat in Nellimarla mandal of Vizianagaram. In the village of A T Agraharam, four sampling stations were selected for analysis.

Saripalli is a village in Nellimarla mandal of Vizianagaram district in Andhra Pradesh, India, Located on the banks of Champavathi River. In the village six sampling stations were selected for the study.

Nadipalli is a village in Pusapatirega mandal of the district. The village is very near to Konada, where and in which the river Champavathi mixes in Bay of Bengal. From the village five sampling stations were selected for the study.

Konada is a village and panchayat in Pusapatiregamandal of Vizianagaram district, Andhra Pradesh, India. River Champavathi joins the Bay of Bengal near this village. The village situated near the estuary point of the river namely Konada is found to have only open well waters alone.

Water samples from the two reservoirs namely Andra reservoir and Denkada anicut were also collected for the study. The entire topographical and morphometric data of the reservoirs is discussed.

1.3 About Champavathi River

Champavathi is a very small river that rises in the Eastern Ghats at a height of 1200 m above the sea level in Andra village. It flows in the eastern direction and reaches the Bay of Bengal near Konada village after passing through Nellimaria, Saripalli, Gajapathinagaram of Vizianagaram district of Andhra Pradesh. The drainage area of the Champavathi river basin is around 1410 square kilometers. This huge area is divided into Madugula hills, Coastal plains and Vizianagaram plains, which are in the Eastern Ghats Mobile Belt (EGMB). The river basin is filled with earliest geologic period formations of excellent quality metamorphic rocks, Charnockites, constituting Khondalites, Migmatites, Calc-granulites and Quartzites [163-166].

Champavathi River is a water body that is running towards a lower level through a channel on land in Andhra Pradesh. The centre of the river lies in a longitude of 83.46667 and its latitude is at 18.2. It possesses an elevation of 25m above the sea level. Several investigations are done for the exploration of underground water and simulated recharge for improving the level of groundwater in the Champavathi River Basin (CRB).The probable zones of groundwater and pockets for recharge are recognized based on the hydro-geological information and geo-electrical information. The potential of the ground water is classified as poor, medium and good based on this analysis [161].

Groundwater scarcity is one of the major problems in the rigid rocky land of Eastern Ghats, of which Champavathi river basin forms a major part. An ideal exploration method and excellent geological skill are required for delineating the aquifers for ground water. This basin is located in Andhra Pradesh in the Vizianagaram district. This river falls under the medium and non-perennial category of watersheds, which flows via rain fed areas of cultivation [161].

The river is a stream of class H, which means hydrographic, whose coordinates are 18°12’0” N and 83°28’0” E in Degrees Minutes and Seconds or 83.4667 and 18.2 in decimal degrees. The Denkada is a village located on the banks of the river Champavathi and the Denkada Anicut was built between 1965 and 1968, which is situated near the Saripalli village in Nellimarla Mandal of Vizianagaram District. The main purpose of this project is to provide irrigational facilities for approximately 5153 acres of land, which works out to approximately 20.85 square kilometers [161].

Jagadeeswara Rao et al [155] elaborately presented the groundwater packets and recharge zones and the geo electric data analysis of Champavathi river basin. In their article they mentioned about the nature and composition of the soil through which the river flows.

Sridevi [156] presented a detailed description about the parameters such as pH, salinity and microbial analysis in their research article about the microbial studies on the Champavathi river estuarine bacteria in east coast of India.

The details of the two reservoirs under study are presented below.

Andra reservoir

Andra reservoir project (Fig. 1.3.1) is medium irrigation project, constructed across the river Champavati at Andra village situated in Mentada mandal of Vizianagaram district of Andhra Pradesh, India. Andhra is located at 18.3500°N 83.2000°E. The Andra reservoir project is situated in the coordinates of 18.338904 latitude and 83.194372 longitudes. It has an average elevation of 127 meters (419 feet). It is constructed to irrigate a total ayacut of 9,426 Acres in Vizianagaram District. The

Project utilizes 0.980 TMC of the available water and the Reservoir Storage Capacity is 0.98 TMC (Gross) and 0.932 TMC (net). The ayacut of 9426 Acres has been stabilized in Bondapalli, Gajapathinagaram &Mentada Mandals of Vizianagaram district [161].

Denkada anicut

The Denkada Aniuct (Fig.1.3.2) was constructed across Champavathi River The Project is located near Saripalli village, Nellimarla Mandal, Vizianagaram District to irrigate a total ayacut of 5,153 acres in the District. The project was constructed during 1965-68. The Project utilizes 0.640 TMC of the available water. The Denakda anicut was situated in the coordinates of 18°7'51"N 83°28'36"E [161].

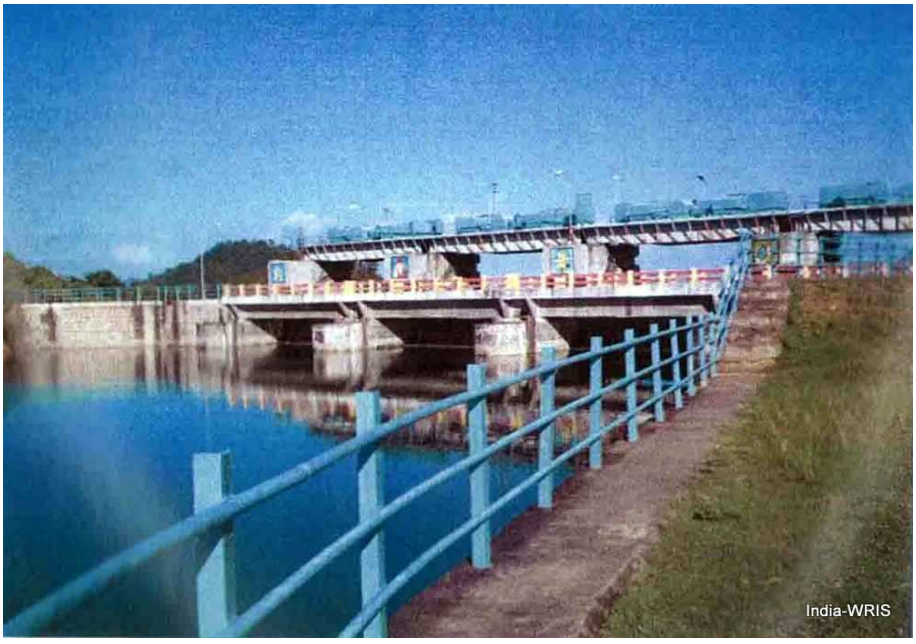


Fig.1.3.1 Andra Reservoir

Fig. 1.3.2 Denkada Anicut

As mentioned in the earlier paragraphs, groundwater scarcity is one of the major problems in the rigid rocky land of which Champavathi river basin forms a major part. Besides scarcity of groundwater, if the available water is contaminated by household seepage and others, the situation becomes worse, causing serious problems to the residents. In literature it was found that extensive research work was not carried out by researchers to assess the quality of the water sources available such as groundwater and reservoir water on Champavathi River. Hence the author probed into the problem selected.

1.4 Aim of the present work chosen by the author

It is assumed that by 2020 Vizianagaram district will become an industrial hub. Both the Government of India and State Government of Andhra Pradesh are planning for such. It was published in Gazette of India that Vizianagaram district of Andhra Pradesh as one of the economically backward districts in the country. Srikakulam district bounded at East of the Vizianagaram district is well known for pharmaceutical industrial belt

(Pydibheemavaram village). A blueprint was developed by the state and central governments for industrial development in Vizianagaram district too.

For any industry, research organization or academic institute to establish the prerequisite is the availability of water. The present study of the author is focused at the assessment of water quality of groundwater of the selected villages in the vicinity of Champavathi River and reservoirs constructed on the river.

From the literature survey, it was found that the assessment of water quality of rivers, groundwater, reservoir water and estuarine water is performed by the researchers globally to ascertain the suitability of the water for human consumption.

The factors such as scarcity of fresh water, contamination of the available surface & ground waters, and human health issues made the author to select the present problem under investigation to give a baseline data for further studies.

1.4.1 Objectives of the study

1. Seasonal variation in the Physico-chemical characters of the groundwater and reservoir waters
2. Computation of water quality index, assessing the suitability of water for drinking, and irrigation purposes.
3. Heavy metal analysis
4. Analysis of reservoir water for irrigation and drinking purposes

The author undertook the study to assess the quality of water in the vicinity of the river. A software program in JAVA (Appendix-II) was developed and used by the author for the calculation of water quality index. The results of the investigation for four year duration (11 seasons) are discussed and presented in the thesis.