

# “ENVIRONMENTAL PROBLEMS ON WATER RESOURCES OF BHARATHAPUZHA RIVER-SYSTEM”

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**ORIENTAL RESEARCH CENTRE  
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**CULTURAL GEOGRAPHY AND HABITAT OF NILA RIVER VALLEY -  
MAJOR RESEARCH PROJECT, UGC, NEW DELHI**

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Certified that the report is a part of the work done under UGC Project conducted by the Principal Investigator, under the supervision of Dr. N. M. Nampoothiry, Research Guide of UGC, Major Research Project (1999-2001) and a part of the UGC Report (Final), submitted to the UGC by the Principal Investigator.

(Dr.N.M. Nampoothiri)

**Environmental Problems on Water Resources of  
Bharathapuzha River-System**

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## **PREFACE**

Bharathapuzha is the longest river in Kerala and the second in water resources. It never used to desiccate in olden days but, now-a-days it dries up before the summer. Secondly, some problems are seen on water resources of the river-system and the originality of body of the river has been changed. The problems on water resources of the river-system and the changes on it's shape of originality are the facts, directed to think about it because, the pollution on all characteristic of air, water and land are finally leading to the desiccation of rivers so that, the much of inspiration from my friends and relatives, I decided to conduct the studies on this area, under the Major Project of the UGC "Cultural Geography and Habitat of Nila River Valley", which was headed by Dr. N.M. Nampoothiry.

The work emphasizes the environmental problems on water resources of the river-system and seriousness of "River-Pollution", a cankerous disease and it's difference between the pollution on river water and its priority. Topics are treated in a multi-disciplinary way, using principles of hydrology, geology, hydrodynamic, various branches of engineering and the natural and social science, so that the reader does not need a background in these disciplines. While elementary calculus is used in the derivation of some of the equations, the work as a whole does not require special knowledge of mathematics.

The work will enable the students, researchers and the practitioners in hydrology, engineering, geology, agriculture and other disciplines concerned with ground water.

I hereby expressing thanks to the UGC and the Principal Investigator Dr. N.M.Nampoothiry and the Oriental Research Centre, for giving me the valuable chance to conduct the studies under the Major Research Project, conducted during the period 1999-2001.

## **CHAPTER I**

### **Introduction**

#### **I-I Background of the Study**

Bharathapuzha is the longest river in Kerala and the second in water resources. Out of 444 villages situated in the district of Palakkad, Thrissur and Malappuram, 173 villages are depending the sources of the river. The river is associated with many Gods, thus giving a touch of divinity and holiness. It never used to desiccate in olden days, but now-a-days it dries up immediately after the rainy seasons and recently she has changed her shape of originality and formed as a grazing land, without serving any purpose for which a river is meant. Now she is in advanced stage of death by the cankerous disease.

Till the time any society or samithies organized to protect the river did not take any initiative to do the research work to find out the reasons for the pollution of river. In this circumstance, much of inspiration from my friends and relatives, I ventured to accept the task of investigation on this problem on water resources of the river, which was accepted by the Principal Investigator of UGC Project and under his guidance, I have completed the work.

#### **I-II Objectives of the Study**

The cry of pollution is heard from all nooks and corner of the globe and pollution has become a major challenge of our time. Secondly, almost all types of pollution finally leads to the reduction of sources into the rivers. But, the development of nations and pollution control of the rivers are equally important. Keeping this in view and realizing the necessity, I decided to do an investigation to assess about the problems on water resources of Bharathapuzha river-system and the remedies.

### **I- III**    Significance and Relevance of Study

Pollution of the river water and the pollution on the water resources of the river are commonly known as the river pollution. But in the hydrological observation on the river, both are entirely different. Destroying the purity in originality of the river water by discharging the sewages, factory effluents and inorganic chemicals, etc into the river is called the water pollution of the river. Destroying the purity in originality of the body of river by desiccating through the anthropical activities and the co-ordinated reasons can be called or named as the river pollution.

Till the time, there is no such a pollution on the body of the river other than the pollution on the river water. Therefore, river pollution is a new and growing chapter within the subject of environmental science. The significance and the relevance of the study of river pollution is a present day problem.

### **I-IV**

## Methodology

Scientific and social method of observation is adopted to determine the fact. Primary data is collected from the available books and the official records. Secondary data regarding potential developments on the river-basin, physical and social infrastructure, etc available is collected from various departments and the related organizations. Apart from the above, some photos are collected to show the particular matters, which cannot be proved by any other ways.

By the social methods, I had done a number of interviews to secure certain information from the subject which is known only to himself and cannot be gathered from any sources and the laboratory study of verbal behavior under a given circumstance.

In addition to these, I am herewith exposing some facts by my experience on investigation of water resources for the wells and tanks, during the period of last twenty five years and more.

## CHAPTER II

### Definitions of “River” and “Pollution”

#### **II-I** Concept of term “River”

Every tract of land on the surface of the earth is marked by irregularities. As a result, when rain falls or glacier melts or spring water sprouts or lake overflows outward and downward taking the shortest route. Thus the little gutters are formed. Such gutters are miniature streams and perform the same type of action on small scale. The gutters thus formed will converge at a latter period downward and their union forms a streamlets. Several such streamlets unite at still downward regions and form streams. In this way, a complex branching type of drainage system will be developed upon the area. When a bigger body (unions of several streams) of flowing water constrained in a channel, it may be defined as ‘River’.

Environmentally, the term is used for the main trunk of a drainage system of nature, which have been used to renounce the excess water and wastes, etc

from the earth in nick of time to protect the nature and also to meet the basic need is indicating the sign of River, playing a major role in self protective system of nature.

## **II- II Definition of the term 'Pollution'**

Pollution can be defined as undesirable changes in physical, chemical or biological characteristic of air, water or land that can harmfully affect the health, survival or activities of human or other living organism. When the man and animal began their life on earth, there was absolutely no sign of pollution. There was perfect balance on various natural processes. The air and water were pure and soil was fertile. The problem of pollution arose with the very civilization of man.

Today the cry of pollution is heard from all the nooks and corners of the globe and pollution has become a major challenge of our time. But the problem of pollution is of different types in different places. Hence, some problems on the water resources of Bharathapuzha river-system and some changes on its shape of originality is the fact, directed to think about it.

## **CHAPTER III**

### **Geomorphology of Bharathapuzha**

#### **III-I Introduction**

Rivers are alimented by both surface and underground water. The quantitative significance of these two water types to river alimentation is controlled by geomorphic, climatic and hydrologic condition of that region. When natural balance disturbed by the anthropical activities and the co-ordinated reasons, results to dry up the water-course. Therefore, the process of investigation is initiated through the geomorphological condition of the basinal area. Hence, configuration of the river-system, length and hydraulic gradient declivity from side extremities, area of river-basin and its geological condition, etc are dealt in this

chapter with a view to get the details of problems which are affecting on water-course of the river.

### **III-II** Configuration of River-System

Bharathapuzha river-basin is located within  $10^{\circ} 20'$  and  $11^{\circ} 05'$  north latitude with  $75^{\circ} 55'$  and  $76^{\circ} 57'$  east longitude of Greenwich in Kerala State – Ref: Kerala Drainage, Plate No3, Water Atlas of Kerala, 1995.

The peculiarity in traverse section of the river is that it originates from the Anamudi Peak having a height of 2695 mts above MSL on Anamalai Hill range in Devikulam Taluk, Idukki District, Kerala State, the southern portion of western ghats. As in Fig No III-II-I, after traverse in north eastern direction through the upper reservoir it falls in the main dam of Aliyar constructed at the level of 300 mts MSL in south Pollachi, Coimbatore district in the eastern side of western ghats. The river is called Aliyar in Tamil Nadu. It runs in north-western direction and confluence with another river called Palar, originates from another part of the same hill range. Then it flows west into Kerala through the Palakkad gap, having 32 km width, comprised in western ghats, originator of the river.

As in Fig No: III-II-II, the river flows in Kerala along the length of gap with common name Ponnani river, called 'Bharathapuzha' with procuring number of tributaries, such as Kalpathipuzha called Varatar in Tamil Nadu, Cheerakuzhipuzha and Thuthapuzha, etc with their branches known by different

names in different places, then join in Arabian sea at Ponnani in Malappuram District, Kerala State with accepting a devine name called “Nila”.

### **III- III** Length and Hydraulic Gradient

According to the length and hydraulic gradient, taken from the physical map, provided from the Office of the Survey of India, Palakkad, Kerala State, the river flows 255 km length in 3 phase of its journey with variable gradient. In the first phase, it traverse approximately 46 km length in hilly track and then fall in the Aliyar dam constructed at 300 mts above MSL in eastern side of the Anamalai hill range in Tamil Nadu. In the second phase, it traverses 54 km length from the dam to the Kerala-Tamil Nadu boarder with the average gradient of 2.31 m per km in length.

In the third phase, it traverse 155km length in Kerala with variable gradient as shown in Fig No:III-III-I and confluence with Arabian sea at Ponnani. But, now-a-days, the recorded gradient has been changed by the indiscriminate sand-drawal on the river-bed.

### **III- IV** Declivity from side extremities

As on visuality the land on either side has no slope towards the river. But, as a result of the river flowing along the gap length the mountains, which raised on either side of the gap (as in Fig No: III-II-II above) produced the declivity towards the river. Recordical evidence about the rate of slope is not available. However,

the tributaries (as in Fig No: III-II-I above) from the tract of mountains on either side are indicating the phenomena of slope towards the river, which in turn, has led to the speedy flow of rainwater towards the seaward course. Hence, the side slope results to the more erosional damages on the basinal area.

### **III-V** Area of River-Basin

River system dominated on 6186 km<sup>2</sup> area on the earth surface. Out of this, 1786 km<sup>2</sup> area is located in Coimbatore District in Tamil Nadu. The remaining 4400 km<sup>2</sup> area comprised mostly in Palakkad District and the rest of it contain in Thrissur and Malappuram Districts in Kerala State - Ref: Plate No: 43 Bharathapuzha Basin, Water Atlas of Kerala, 1995.

### **III-VI** Geological Condition of Basin Area

Physiographically, the area of river-basin is divided into 3 parts. They are the upper, middle and the lower. Upper part is covered by the hilly tract of western ghats. In the middle part, only the few area of plain land is available in Coimbatore District of Tamil Nadu and in the east and south vicinity of Palakkad town in Kerala State. The balance area of middle part and the entire area in lower part are covered by hillocks and small mountains made up of harder, durable and resistive substance of laterite, bed rocks and belt of hard rocks.

Coverage of these hills and mountains produced the irregularities of earth surface reasoning to the countless number of water-course towards the river.

### **III-VII** Summary and Conclusion

Bharathapuzha originates from the Anamudi Peak having a height of 2695 mts above MSL on Anamalai hill range in southern portion of western ghats. The middle and lower part of a river flowing through a gap length is its peculiarity. It flows 255 km length in three phases of its journey with variable gradient. The tall mountains raised on either side of the gap length produced the declivity of sides towards the river. Within a short distance of its flow the river-system dominated on 6186 km<sup>2</sup> area on the earth surface. The irregularity of basinal area by the mountains and hillocks produced the number of water-course towards the river. Coverage of earth surface by the resistancive substance of laterite, bedrock and the belt of hardrocks are reasoning to the reduction of rain water infiltration within a period of rain falls. Even such a condition, the river had flowed even in the summer of olden days. But, now-a-days, the river dries up before the summer. Therefore, an investigation through the discernible changes on the earth surface is foremost.

## **CHAPTER IV**

### **Discernible Changes on the Earth Surface**

#### **IV- I    Introduction**

Basin area of the river in Kerala comprised mostly in Palakkad District.

Therefore, the discernible changes on the area of Palakkad District is dealt in this

chapter with a view to find out the total changes on the basinal area and its consequence.

As a result of the population growth and developments, the area of local forests on the isolated mountains and hillocks are give-ground to the rubber plantations. Secondly, the agricultural lands have been converted into the industrial and its pertinent necessities. Hence the natural settings of the topography have been changed into some other ways. Therefore, the discernable changes on the earth surface, such as the coverage of shelter, coverage of tar and concrete roads, loss of flood plains, loss of natural forest coverage, and the domination of rubber plantations, etc on the area of Palakkad District is dealt in this chapter with a view to find out the consequence of changes on the river-basin.

#### **IV-II-I** Coverage of Shelter

#### **IV-II-II** Introduction

Once the area of Palakkad was an agrarian belt, changed into a major industrial centre of Kerala. Secondly, the joint family system of human life is changed into

the nuclear family life. Thirdly, the Gulf money much influenced on rural areas. Fourthly, population has been concentrated in rural areas. Therefore, these developments are dealt in this chapter with a view to find out the coverage of shelter on the basinal area.

#### **IV-II-III Industrial Developments**

Climatical, geological, and geographical conditions, availability of land with less cost rate, transportation and water facilities, vicinity of the major industrial centre at Coimbatore, in neighboring State, etc enticed the industrialists to concentrate at Palakkad. Hence, the Palakkad became a major industrial centre of Kerala State. As per the record in District Industries Centre in Palakkad, there are forty-eight number of large and medium scale industries in Palakkad District.

The number of SSI (Small Scale Industries) units registered in the district upto 1983 – 84 is 1524 and it has grown up to 6525 within the period of 1992-93. As on Table No: IV-II-II-I, the growth of SSI units in Palakkad was increased at a high rate during the period of 1985-89 and then keeping the stagnancy around 14%. Hence, Palakkad is a major industrial centre in Kerala, produced the wide area of shelter by its buildings.

#### **IV-II-IV Institutional Buildings**

As on Table No:IV-II-III-I, there are 2015 institutional buildings located in different areas of Palakkad district. In addition to these, the number of institutional

buildings such as the buildings of civil station, district and taluk courts, buildings for the police and forest departments and the recreational buildings are balanced to be recorded. The array of these buildings produced the large area of shelter on earth surface.

#### **IV-II-V** Change of Joint Family System

The joint family system of human life is changed into the nuclear family life. But, recordical evidence is not available to exhibit this phenomena. Whereas the growth in number of individual unit of ration cards by removing their names from the combined cards and the family partitions, recorded in Sub-Registrar Offices are the evidence, surmised the changes. It is reasoning to the multiple growth of residential buildings and the wide area of coverage on the earth surface.

#### **IV-II-VI** Influence of Gulf Money

It is the general opinion that the employment opportunities with high level salaries in Gulf countries are much influence on the construction activities in Kerala, particularly in rural areas. But, recordical evidence is not available to accept this. Therefore, I had done a direct survey on the RCC buildings constructed in a cluster of ten Panchayaths. By the observation (Table No: IV-II-V-I), it is clear that the buildings constructed by the Gulf money dominated on the rural area because the new and modern buildings with big in size is considered as a status of the Gulf Malayalees. Such an attitude of our people results to the growth in variety of buildings on the earth surface of rural areas.

#### **IV-II-VII** Concentration of People on Rural Area

Availability of land with less cost rate, pollution free atmosphere and other developments are reasoning to the concentration of people on rural areas of the Gram Panchayaths. Therefore, the buildings for various purposes have been increased. Data of buildings provided from seven Panchayaths (Table No: IV-II-VI-I) shows the density of buildings in rural areas. As on recordal evidence, there are ninety Panchayaths combined in Palakkad District. Therefore, the density of buildings in rural areas of the Palakkad District is imaginable.

#### **IV-II-VIII** Summary and Conclusion

Industrial Growth and its pertinent developments changed joint family system to the nuclear family life, influence of Gulf money and the concentration of people on rural areas are reasoning to the multiple growth of buildings on the basin area. The array of buildings in Towns, Municipalities and Panchayath areas produced the coverage of shelter on wide area of earth surface. The increasing area of shelter produced the reduction on area of infiltration, reduced the quantity on rain water infiltration into the earth is reasoning to the reduction of sources to the river.

#### **IV-III** Coverage of Tar and Concrete Roads

##### **IV-III-I**

## Introduction

The roads made up with hard surface of tar and concrete played an important role for the development of nation. But, it creates some problems on water resources of the rivers. Therefore, the history of road in Malabar, conversion to the metal and concrete roads. Domination of the impervious layer of roads , etc is treated in this chapter

### **IV-III-II** History of Road in Malabar

Tipu Sultan (1782-1799) of Mysore was the pioneer of roads constructed in Malabar. Before his time, the wheeled traffic was unknown because the people did not feel the need of road unlike the Tipu brought his artillery into Malabar. He projected the scheme of connecting all the principle places of Malabar by the extensive chain of roads and great part is finished. Feroke, the Tipu's capital in Malabar, was connected with Mysore and Coimbatore by the number of alternative routes. But, whether the Tipu's roads were neither well made nor properly drained, soon fell into disrepair - Ref: Means of Communication, Page 268 and 269, Chapter No: VII, Malabar Gazetteer by CA Innes, ICS.

### **IV-III-III** Conversion to Metal and Concrete Roads

The British supremacy gave birth to the metal roads, pervaded everywhere in the country. Very few number of concrete roads with small in length have formalized in second quarter of 20<sup>th</sup> century. These metal and concrete roads did not create

any impact in the earth - Ref: Means of Communication, Page 267-79, Malabar Gazetteer by CA Innes, ICS.

#### **IV-III-IV** Domination of the Impervious Layer of roads

As a result of the population growth, industrial and social developments, the large number of roads made up with tar and concrete are originated on the earth surface. The roads made up of hard surface with tar and concrete are relatively impervious. Therefore, before getting infiltration the most part of the precipitated water flowing to the seaward course.

As on Table No:IV-III-IV-I, there are 8006 km length of tar and concrete roads with the variant width is dominated on the land surface of Palakkad district. It has been increased in day by day, produced the wide area of impervious layers on the earth surface. The wide area of this artificial layer produced the reduction on quantity of rain water infiltration into the earth. Therefore, the earth is drying up before the summer which in turn has led to the reduction of sources to the river

#### **IV-III-V** Summary and Conclusion

The people of Malabar did not feel the need of road until the Tipu ruled on it. Hence, Tipu was the pioneer of road in Malabar. Afterwards, the metal and concrete roads were originated under the British supremacy. During the period of independent India, the tar and concrete roads pervaded almost all areas of Palakkad district and it covered up more than 8006 km length. Length of these

roads with variant width produced the wide area of impervious layer on the earth surface which has been reduced the quantity of rain water infiltration into the earth and hence to the river.

#### **IV-IV** Loss of Flood – Plains

##### **IV-IV-I** Introduction

It is the general opinion that brick works by using the flood–plain deposit is a reason to the desiccation of the river. Therefore, definition of the term “flood-plain”, its importance and the brick work and its consequence are dealt in this chapter.

##### **IV-IV-II** Definition of the term “Flood-Plain”

Floods are the natural activities of rivers caused by the act of the dynamical agencies of nature. During floods the streams commonly overflows their channels and the deposits are formed. The area on both sides of the river which has been formed by the flood time deposits are called ‘flood-plains’. The brick earth, brick clay and the other mineral deposits of the river provides fertility to these plains. These flood-plains and the growth of vegetation on it, are producing the coverage on earth surface.

##### **IV-IV-III** Brick Works on River Sides

As a result of increasing demand on bricks, brick clay the most suitable soil for the brick works are taken in a large scale from the flood-plain deposits along the

river length. At the same time, the processes of depositing products on the river sides has not been conducted by lack of floods as in olden days. Therefore, the continuous removal of deposits and lack of deposition by the absence of floods are reasoning to the change of topography, losing the fertility of soil and the loss of coverage on the earth.

Loss of this natural coverage results to the effect of temperature on the earth, produced more evaporation through the small holes, opened on the earth. Secondly, the temperature from the brick field and the brick kilns are reasoning to the flow of brick fielder on vicinity, facilitate more evaporation from the land and water surface. Details of evaporation is discussed in Chapter no: VII-VI hereafter.

#### **IV-IV-IV** Summary and Conclusion

Flood-plains are the natural deposits formed by the floods. It provides the coverage on earth and the fertility to the soil. But the large scale removal of this coverage is reasoning to increase the evaporation from the earth. Secondly, the temperature from the brick field and the brick kilns produced the brick fielder, results to the evaporation from the land and water surface.

Recordical evidence is not available to justify the facts, by the limitation on the individual explorer. But the discernable changes on the river sides by removing the natural coverage, the temperature which feel on the brick field, and from the

brick kilns are the feeling of brick fielder in the vicinity are clearly indicating the possibility to facilitate the evaporation from the land and water surface.

#### **IV-V** Deforestation

##### **IV-V-I** Introduction

Forest, the inborn asset, is playing an important role in the self-protective system of nature. But, it has been depleted from some other purposes is against the systematic management of nature, results to the change of eco-system, producing more effects on the earth. Therefore, the definition of the term “forest”, status of forest in Palakkad District, relation between the forest and temperature, forest and rain fall and the forest and water resources are dealt in this chapter with a view to find out the impact by the loss of forests

##### **IV-V-II** Definition of the term “Forest”

The word “forest” is derived from Latin “Foris” meaning outside, the reference being to village boundary or fence and must have included all uncultivated and uninhabited land. Today, a forest is any land managed for the diverse purposes of forestry whether covered with trees, shrubs, climbers, etc or not. (Forestry has been defined as the theory and practice of scientific management of forests, including their creation when necessary, for the continuous provision of produce and services). The Indian word “Jungle” has been adopted in the English language to describe as a collection of trees, shrubs, etc that are not grown in a

regular manner, as contracted with forest, which is any vegetation under systematic management. But, legally a forest is a land including the vegetation growing on it that has been so declared under a legal enactment. Ref: Forest and Forest Management, Page No:1, Occasional Monograph No:12 on Forest, by the Indian Institute of Geology and Environment, New Delhi.

The cited definitions are given much meaning to the forest, but they are not indicating the environmental parameters. Therefore, environmentally, a forest should be an uncultivated and uninhabited land with the total of environmental parameters (The states of ecological, physical environmental, such as sunlight, atmosphere, water and soil or rock and the biological conditions are commonly known as Environmental Parameters) that has been so declared under legal enactment. In these areas, when large trees fall, however, or the forest cleared, then various forms of secondary growth enter, forming the more typical jungle picture. Now-a-days, the area of such a type forest have been reduced.

#### **IV-V-III** Status of Forest in Palakkad

Area of Bharathapuzha basin in Kerala comprised mostly in Palakkad District. So, I think that the studies on area of forest in Palakkad is enough to get the condition of forest on the basinal area.

Once the area of present Palakkad District had a wide area of forest coverage. But, recordical evidence about the actual extent of forest is not available. In this circumstance, an old data (Table No: IV-V-III-I) about the area of reserved forest

and proposed for reservation in Walluvanad, known as Valluvanad and Palakkad Taluks are produced.

As on Table, 1, 09,811.4 acres or 44,440 hectares of forest was available in Valluvanad and Palakkad Taluks of the present Palakkad District. But, the quantity of forest cited in the table is not conceivable because the Angadipuram Village which was the part of Valluvanad Taluk is now in Malappuram District.

Secondly, there is no chance to include the complete area of forest in Attapadi Valley of Valluvanad Taluk, because during that period only 21 hills and the part of another one was belonged to the Government and the 72 hills and part of the eleven others were under three powerful janmis, the Mannarkad Muppil Nayar, Palat Krishna Menon and the Eralpadi Raja, who have in dispute with Government.

After the end of the dispute in 1901, forty four hills and the part of five others have been awarded to the Mannarkkad Muppil Nayar, sixteen hills and part of six others to the Eralpad Raja, ten hills to Palatt Krishna Menon and two hills to other janmi. Hence there is no chance to include the area of forest belonged to the private parties. Therefore, the actual quantity of reserved forest on the area of present Palakkad District was much more than the area cited in the Table - Ref: Chapter No: XV, Valluvanadu Taluk, Page No: 496, Malabar Gazetteer by C.A. Innes, ICS.

In addition to the reserved forest, there were a number of coppice on the local mountains and hills by the private parties. They were called the local forests of Janmis. As a result of rapacity almost all these copse are converted into the rubber plantation and for some other purposes. Only a few of them are balanced and afterwards they are nationalized as vested forests. As on Table No: IV-V-III-II, there are 75,149 hectares of vested forests in Palakkad District. As on above account, the area of local forest in earlier period was conceivable.

As on recordical evidence, provided from Chapter No: 3:9:1, Forest cover, Industrial Potential Survey in Palakkad District, the total area of forest including the reserved forest, proposed for reserved forest, vested forest, wild life sanctuary and the National Park, etc, in Palakkad District during 1990–91 is 1,36,257 hectares. It covers about 30% of the total geographical area of the district.

#### **IV-V-IV** Forest and Temperature

Naturally forests control the temperature of that region by absorbing  $\text{CO}_2$  presence in the atmosphere. But, the development of science and technology and its pertinent developments on one side and the shortage of forest coverage on other side are reasoning to the rise of temperature in Palakkad District. Details of temperature are discussed in Chapter No: VI-II-I hereafter.

#### **IV-V-V** Forest and Rainfall

As on Table No: IV-V-V-I, there is a marked variation on the rain fall in side extremities and the central area of the river-basin. While getting 2668 mm and 2304 mm rainfall respectively on the hilly tract of South and North extremities, the only 1631 mm rainfall is available on central area of the basinal width. The higher rainfall of 2630 mm which gets in lower regions of the basinal area is quite natural by the vicinity of the sea. Hence, the quantity of rainfall which gets in central area is comparatively less when it is compared with the side extremities because the reserved forests in Palakkad District concentrated mostly on the hilly tract in North and North-East extremities of the basinal area. The hilly tract on the South extremities contain in Thrissur District having forest coverage with 34.61% of the geographical area of the district (Plate No:13, Land Use Water Atlas of Kerala). The hilly tract and its wide area of forest coverage in extremities, providing facilities to the condensation of clouds, accumulated on that area. But in plain land, the clouds are being passed off, without getting condensed by the lack of forest coverage because the local forest of these areas are being converted into the rubber plantation and for some other purposes. Hence the loss of natural forest coverage, results to the reduction of rainfall on the plain of river-basin.

#### **IV-V-VI** Forest and Water Resources

Recordical evidence is not available to show the relation between forest and water resources. Therefore, I am herewith exposing some facts by my experience on the investigation of water resources for the wells and tanks.

In the presence of vegetative cover the rain will not be able to compact the soil. Secondly, it also provides a layer of decaying organic matter, promote the activities of borrowing insects and animals, which in turn produces permeable soil structure. Both of these factors help to increase the infiltration capacity of that soil to a considerable extent. But, depletion of forest removes the protective cover over a soil and remove the cushion of falling rain drops. This increases their impact and consequent damages. Destruction of forest remove the obstacles in the path of flowing water which increase the surface run off, produced the reduction on quantity of infiltration.

Vegetation is the most important factor for the preservation of water sources, because where there is a dense forest or the thick vegetations, there the vaporization cannot happen. But, the absence in sufficient area of natural vegetation is reasoning to increase the vaporization.

The river basin has no wide area of vegetations, other than the forest in side extremities. Therefore, it is very difficult to preserve the water sources because the quantity of infiltration has been reduced, whereas the vaporization has been increased. Hence, the sources to the wells and tanks are automatically reduced before the summer, leading to the seasonal drought on the basinal area, which, in turn, has led to the reduction of sources to the river.

#### **IV-V-VI** Summary and Conclusion

There are a number of definitions regarding forest. But, they are not indicated in the environmental meaning of forests. Therefore, environmentally, a forest should be an uncultivated and uninhabited land with some total of environmental parameters and it should be declared under legal enactment. As on available record, there were 1,09,811.4 acres (44,440 hectares) reserved forest on the area of present Palakkad District. But, the quantity is not conceivable by the omission of 72 hills and the part of another eleven hills in Attapadi Valley. Therefore, the actual quantity of reserved forest in earlier period was much more than the area, cited in the record.

The area of present Palakkad District had a large number of coppice, known as local forest by the private parties. But, most of them were converted into the rubber plantations and for some other purposes and only 75,157 hectares of local forest is balanced as vested forests. Therefore, the total quantity of local forests which had lost by the deforestation is beyond that we can assume.

Despite the area of forest has been decreasing, totally 1,36,257 hectares of forest coverage (including reserved forest, proposed for reservation, vested forest, wild life sanctuaries and the National Park) is balanced in Palakkad District. But, it is only 30% of the geographical area of the district. Therefore, the quantity of forest which had lost in Palakkad is to be considered.

Industrial and its pertinent developments, population concentration and its natural growth, etc on one side and the reduction in quantity of forest coverage on other side result to the increase of temperature in Palakkad.

Wide area of forest in side extremities of river-basin facilitate the heavy rainfall on that regions. But, the clouds which accumulated along the central part is moved without getting condensation by the lack of forest coverage, reducing the quantity of rainfall.

Loss of forest is reasoning to the reduction on quantity on rain water infiltration into the earth. Secondly, the evaporation from the land is increased by the deforestation. They are leading to the desiccation of earth before the summer which, in turn, has led to the seasonal drought of the river.

#### **IV-VI** Domination of Rubber in Kerala

##### **IV-VI-I** Introduction

Domination of rubber in Kerala is a noted issue, regarding desiccation of the water resources. Therefore, details about the growth of rubber in Kerala and the environmental role of rubber are dealt in this chapter with a view to find out the impact on water resources of the river system.

##### **IV-VI-II** Growth of Rubber in Kerala

Physiographical condition of Kerala, periodical supply of rainfall, increasing rate on cash crops, marketing facilities of rubber and the rapacity of human being are the reasons to induce to the rubber plantation in Kerala. As a result, the area of local forests on the isolated mountains and hillocks are converted into the rubber estates. Hence, the rubber dominated on the earth surface in Kerala.

#### **IV-VI-III** Status of Rubber in Palakkad District

Recordical evidence about the actual extent of rubber crop in Palakkad is not available by the lack of registration with the Board. While the information from the Table No: 3:4:2, in production of important crops, industrial potential survey in Palakkad District shows that the production of rubber in 1990-91 was 14660 tones. But, the quantity taken by the open market is additional. By this, the total area of rubber crop to get such a great quantity of products is imaginable.

#### **IV-VI-IV** Environmental Role of Rubber

Recordical evidence about the environmental role of rubber is not available. Therefore, I am herewith exposing some facts by my experience on investigation of water resources for the wells and tanks in rubber estates. They are: -

Generally, the area of rubber plantation does not feel the cooling atmosphere as in the area of natural forests. So, the process of condensation is reduced, and results to the reduction in quantity of rainfall.

Warmly atmosphere which feels in the rubber estate is reasoning to produce more evaporation, because the temperature is the main factor of evaporation.

Rubber comes in the deciduous group of vegetation and the foliation takes place in autumn and reproduce the leaves copiously before the summer. Therefore, loss of water by the transpiration processes is more because the role of transpiration depends upon the sunlight, available moisture and the stage of growth.

Activity of burrowing insects is comparatively less in rubber estates by using pesticides. Therefore, infiltration process is reduced.

Rubber, the lactifluous plant, extract more water from the ground. Hence, the earth is quickly dries up.

A number of parameters are required to justify the matter. But, in the light of above said reasons, it is my suggestion that the rubber estate wither the earth, which leading to the destruction of ground water in the area and its vicinity, after-effects to the desiccation of rivers.

## **CHAPTER V**

### **Vibration on Earth Surface**

#### **V-I Introduction**

Surface of earth is in a perpetual disturbance due to different kinds of vibrations. Most of these vibrations are so feeble that cannot feel them. Only a few are severe enough to have disastrous effects. These vibrations both feeble and strong set up on earth surface by any reasons, creating problems on water resources of that area. Therefore, the mining activities, fire works in festival grounds, blasting works in wells, micro seismic activities on the river-basin are

dealt in this chapter with a view to find out the relation between the surface and underground drainage of the basinal area.

## **V-II** Mining Activities

Our state in India has not yet been advanced in large-scale mining activities other than the production of boulders and metal for construction works and limestone for cement production, which are coming under the group of opencast mining. As a matter of fact, this small scale mining activities are also creating problems on the earth.

Recordically, there is no more quarries working in Palakkad District. But, by the investigation nearly thousand quarries are seeing as worked in Palakkad District.

The daily use of high power explosives in a competitive work of producing materials in each quarries in a day, produced the local level vibrations on the earth. But the continuous and chainage of vibrations from the numberless quarries produced the effect on wide area of the earth surface.

An appropriate data about the intensity of vibration on earth by the mining activities are not available. But, the propagation velocity of longitudinal seismic waves through the seven categories of soil (Table No: V-II-I) expressed the idea about the intensity of vibration by the velocity of waves through the various soils

by the action of force. It helps to understand the force of vibration on the earth surface by the mining activities.

Specified data about the reduction in quantity of rain water infiltration by the quarry works are not available, because it depends upon the topography, porosity of the soil and the climate on that region. But, the continuous force of vibration, loosened the natural compactness of earth crust, leading to the weathering effect and also reasoning to expose the old cracks and joins in the earth. In such a type of places, numerous pours are visible at the time of continuous rainfalls and are drying up along with the fare-well because before getting infiltration into the deeper level the precipitated water flows to the outer place through the joints and cracks. Thus, the quantity of infiltration has been reduced which, in turn, has led to desiccate the surroundings before the summer.

### **V-III Fire Works in Festival Grounds**

The yearly conducting summer festivals, related to the place of worship, is the part of our culture and heritage. The large quantity of explosives with the average weight of 100 kg/ one is used in the competitive fire works in festival grounds. Therefore, the force, which acts on the ground to rise up these explosives at an altitude of average 30 mts, produced the local level vibrations on the earth surface.

An appropriate data about the number of yearly conducting festivals, related the place of worship, is not available. But, by the investigation through the senior persons who are the active participants in fire works in temple festivals, I have got an idea of nearly thousand number of yearly conducting festivals, related to the place of worships is being celebrated in Palakkad District.

The chain of festivals by the system of celebrating anywhere in a day, produced the perpetual disturbance of local level vibrations. This vibration results to the loss of natural compactness of earth surface which leads to more weathering effects and to the reduction in quantity of rain water infiltration into the earth, by the reasons as described in Chapter V-II above.

#### **V-IV** Blasting Works in Wells

Due to the lack of knowledge on hydrological condition of their plots, many of the people in rural areas are constructing their wells according to their own convenience is reasoning to the blasting of rocks in wells. In this connection, I have got a chance to inspect a number of wells by the request of parties.

In order to get more knowledge about the subject, I approached some experts in the field of rock blasting in wells. According to them, loss of water by the blockage on water transit to the wells are quite natural by the indiscriminate method of rock blasting in wells.

Absence of knowledge on the blasting technology of rock in well is reasoning to produce the faults (Fig No: V-IV-I) in the layer of rock underneath the wells. The fractured blocks are sometimes slipped off each other, cut the relationship between the existing part of the layer and the slipped blocks. Therefore, the wells constructed in the slipped blocks are drying up by the faults across the waterways. Secondly, the water, which gets by the rainfall and earth bleeding are flown to the outer place by this water transit. Whereas, the wells on the existing part of the layer indicate the rise of water level by this blockage.

The surface of earth is in a state of perpetual disturbance due to different kinds of vibrations. Therefore, the rise and fall of water in the wells of Kerala is an important issue to think about.

#### **V-V Microseismic Activities on River-Basin**

A large physiographic feature spanning from Coimbatore in Tamil Nadu to the Vadakkanjeri in Thrissur District of Kerala is a major shear zone passes through the Palakkad gap (Fig No: V-V-I). The east-west orientation of this geomorphic feature including that of Bharathapuzha is in general agreement with the trend of the structure. While the Coimbatore earthquake in 1900 occurred in eastern side of Palakkad gap, the Vadakkanjeri earth quake (Fig No: V-V-II) sequence in 1994 originated in western extremity. Secondly, the scientists in Centre for Earth Science Studies, Thiruvananthapuram forecast the potential to generate the earth quakes within the confines of Palakkad Gap in future.

Association of well-known tectonic structure with Bharathapuzha and the tendency of seismic activities with its frequencies (Table No: V-V-I) shows the trend of micro earth quakes on the river- basin. Ref: a report on December 2<sup>nd</sup> 1994 Vadakkanjeri earth quake and low moderate seismicity in the vicinity of Palakkad Gap in South India and its implications – Vol. 70, by the Centre for Earth Science Studies, Thiruvananthapuram.

#### **V-VI** Relationship between the area of Surface and Underground Drainage Basins.

It was proved that, depending on topography, the degree of its dissection and on the geological structure, the relation between the surface drainage basin and underground drainage basin can be variable. In some region, the surface drainage basin and underground drainage basin are equivalent (Fig No:V-V-I). In others, the area of the surface drainage basins are greater than those of the underground drainage basins (Fig No:V-V-II). Where as, sometimes, the underground drainage basins are considerably larger than the surface drainage area (Fig No:V-V-III).

According to the basinal area, the surface of earth is in a perpetual disturbance by the human activities and the natural causes. Therefore, the relation between the surface drainage basin and underground drainage basin can be variable. This gives rooms to the differential infiltration process to take place.

## CHAPTER VI

## Climate

### **VI-I** Introduction

Climate is a major factor of river alimentation. But, now-a-days, some changes are seen on the temperature and rainfall on the basinal area. Therefore, the temperature of Palakkad during the period of British rule and in present and the scheduled quantity of rainfall to the basinal area, the quantity of rainfall which had been received in available period of 1979-92, the comparison of rainfall with the earlier period of 1901-1907 and the season-wise and area-wise rainfall and the intensity of wind on basinal area are dealt in this chapter.

### **VI-II-I** Temperature of Palakkad during the period of British Rule

Data about the temperature of Palakkad, during the earlier period is not available. But, the area of Palakkad lies between Cochin and Calicut taluks of Malabar District. Therefore, I am herewith lightening the recordical evidence (Table No: VI-II-I) about the temperature of Cochin and Calicut taluks with a view to find out the temperature on the area of Palakkad.

As on Table, the maximum temperature in Cochin and Calicut was 91.5<sup>0</sup> F and 91.3<sup>0</sup> F respectively equal to 34.53<sup>0</sup> C and 34.452<sup>0</sup> C. Therefore, the temperature of Palakkad might be equal to the average of

$$\frac{34.53+34.452}{2} = 34.491^{\circ} \text{C}.$$

### **VI-II-II** Temperature of Palakkad during 1993-99

Due to the lack of recording stations, the temperature of various locations are not available. Hence, it is very difficult to substantiate the actual temperature of the river-basin. But, the available period of temperature, provided from two recording stations, one at Palakkad and the other one in Malampuzha shows (Table No: VI-II-II-I) the increasing trend of temperature in Palakkad. The temperature recorded by the stations has no more difference. Secondly, the slight difference on the recordings are quite natural because the recording station at Palakkad is in centre of the town, always produce more temperature. But, in Malampuzha, naturally it has reduced by the vicinity of dam. Therefore, the average of these two:  $39.4+38.96 / 2 = 39.18^{\circ}\text{C}$  is considered as the temperature of the basinal area.

### **VI-II-III** Conclusion

As per the available data, the temperature in earlier period of Palakkad is  $34.491^{\circ}\text{C}$  and at present is  $39.18^{\circ}\text{C}$ . Therefore, the rise of temperature in Palakkad is  $39.18 - 34.491 = 4.689^{\circ}\text{C}$  is indicating the dangerous sign of climate, leading to the diversion of rainfalls by the climatographical changes.

### **VI-III-I** Rainfall

#### **VI-III** Quantity of Rainfall scheduled to the Basinal area

The monsoon of India had supplied the periodical rainfall, which fed the rivers of Kerala. But, there is a marked variation on the amount of rainfall to each and every river-basin in Kerala. As on Table No: VI-III-I-I, while getting 4500 mm of rainfall on catchment area of the river - Kuttiyadi in Calicut, the catchment area of Bharathapuzha is getting an average of 2300 mm.

According to the Table No: VI-III-I-II, 63.5% of the total rainfall which gets in 75 days by the south-west monsoon. The over and above quantity of rainfall which gets in 75 days shall not sustain either by the earth or the dams constructed on the river-head. Hence, more than 60% of the rain water unnecessarily flows to the seaward course. Whereas, 19.17% of the total rainfall, which gets in 22 days by the north-east monsoon used to retain quantity of water contents in the earth is helped to the continuous flow of river. Balance 17.33% of the total gets by the summer showers in 21 days of duration, helped to maintain the flow of river in summer. In this way, the river flowed continuously by the blessing of monsoons and periodical summer showers.

#### **VI-III-II** Rainfall During 1979-92

As on recordal evidence, the quantity of rainfall scheduled to the river-basin is 2300mm. But the Table No: VI-III-II-I indicates the variations on it. During the period of 1979-81 the river-basin had blessed with more quantity, than scheduled by the nature. In 1982 – 89 periods, it has been lowered upto 1822 mm. Again the quantity of rainfall increased upto 2560 mm in 1992. Hence, some variations are seen on its quantity of rainfall in 1979-92 periods.

#### **VI-III-III** Comparison of Rainfall with the earlier period of 1901-1909

As on Table No: VI-III-III-I, the area of Mannarkad, Ottapalam, Alathur and Palakkad are indicating more quantity of rainfall in earlier period of 1901-1909, when it compared with the later period of 1979-92. But, in Parli which indicates more quantity of rainfall in later period. Secondly, the rainfall of Alathur indicates much less than the basinal average of later periods. But, the rainfall of Palakkad is always less than the basinal average. Hence, the table shows the variation on the quantity of rainfall in periods.

#### **VI-III-IV** Season-wise Rainfall

The annual rainfall of 1979-92 and its comparison with the earlier period of 1901-1909 shows the variations on the quantity of rainfall on river-basin. Therefore, an investigation on the season-wise rainfall is necessary to substantiate this. But, due to the non-availability of daily recording data of long period, I am hereby showing the available period of rainfall (Table No: VI-III-IV-I).

As on table, the monsoons and summer showers are failed to supply the scheduled quantity of rainfall in 1989 and 1990. But, the south-west monsoon had blessed with more quantity of rainfall in 1991 and 1992. At the same time, north-east monsoon and summer showers are failed to supply the scheduled quantity in 1991 and 1992.

As on above, the south-west monsoon has no reduction on the quantity of rainfall, other than some variations. But, the north-east monsoon and summer showers have been failed to supply the scheduled quantity of rainfall.

#### **VI-III-V** Area-wise Rainfall

Periodical rainfall of 1979-92 and the comparison with the earlier period of 1901-1909 are showing some variations on its quantity of rainfall. But, it is entirely different in season-wise analysis of rainfall because the south-west monsoon shows the variation on its quantity of rainfall and the north-east monsoon and summer showers indicates the reduction on its quantity. Therefore, area-wise analysis is essential.

For the convenience of study, the entire area of the river-basin is divided into four divisions. They are, the hilly tract in north and south extremities of the river-basin, the plain land and the lower part in the vicinity of the sea.

As on Table No: VI-III-V-I, while getting 2668.5mm rainfall on south extremity, the north which gets 2304.189mm. At the same time, the plain of river-basin is

getting only the 1631.5mm. But, the 2630mm rainfall which gets in the lower part is quite natural by the vicinity of sea. Hence, the rainfall on the plain is very less, when it compare with the basinal average of 2300 mm scheduled by the nature.

#### **VI-III-VI** Summary and Conclusion

The monsoon of India had supplied the periodical rainfall, which fed the rivers of Kerala. But, there is a marked variation on the quantity of rainfall on each and every river-basin. The scheduled quantity of rainfall on Bharatapuzha is 2300mm. Out of this, 63.5%, which gets in south-west monsoon shall not sustain either by the earth or the dams constructed on the river bed. Therefore, 60% of the total rain water unnecessarily flows to the seaward course. Whereas, 19.17% of the total which gets by the north east monsoon and the 17.33% by the summer showers had helped to get the continuous flow of the river in olden days.

As on periodical analysis, the river-basin had blessed with more quantity of rainfall in 1979-81 periods. But, in 1982-89, it had lowered upto 1822mm. Again the quantity of rainfall increased upto 2560mm in 1992. Thus it shows the variations on the quantity of rainfall during the periods.

Comparison of periodical rainfall in 1979-92, with the earlier period of 1901-1909 is also supporting to the variation on its quantity.

In the case of season-wise analysis, the south-west monsoon has the variation on the quantity of rainfall. At the same time, the north-east monsoon and summer shower disclosed the reduction on its quantity.

According to the area-wise analysis, the quantity of rainfall, which gets on the plain land of basin area, is very less when it compared with the basinal average, 2300mm scheduled by the nature.

Actually, the long period of data recorded in monthly based is necessary to substantiate the variation and reduction of quantity of rainfall on the river-basin. But, the investigation with available period of data signifying that the south-west monsoon has no more changes other than some variations on the quantity of rainfall scheduled to the basinal area. But, the reduction on the quantity of rainfall has been occurring in the period of north-east monsoon and summer showers. Secondly, the quantity of rainfall, which gets in the plain land is very less than the basinal average. Hence, the status of the rainfall on the river-basin is unfavourable.

#### **VI-IV** Intensity of Wind

The river Bharathapuzha flows along the length of Palakkad gap. Secondly, the wind which flows from the Bay of Bengal is passing through this gap. Hence, there is a chance to intensify the wind on the river-basin. But, specified data about the intensity of wind on the basin is not available.

Total area of the river-basin in Kerala is 4400 km<sup>2</sup>. But, only two observatories, one in Malampuzha and the other at Pattambi are recording the velocity of wind passing through. The other areas have no observatories to find out the wind action.

The Table No: VI-IV-I indicates the more wind action on Malampuzha, but showing merely in Pattambi, because the observatory in Pattambi is located more than 100km far behind from the mouth of Palakkad gap, naturally reduced the velocity of wind. Therefore, the data about these two locations are not enough to justify the wind action on the basinal area. In this circumstance, I decided to go through the conventional method of investigation.

I approached a number of senior citizens having good knowledge about the subject and also residing at different locations on either side of the river. According to them, intensity of storm in summer was dreadful and taking off the thatched roof of huts are quite natural.

In addition to this, I am also an experienced person about the whirl-wind in summer of olden days, because at the time of my S.S.L.C. Examination in March 1963 at Government High School, Pathiripala, Palakkad District, the roof tiles on our school buildings had flown out. The dry leaves, waste papers and the soil

particles, etc had raised into the atmosphere. Such a storms are not seen at present.

Since there is no such a scientific data to prove the wind-velocity on the basin area, the two aspects, such as the wind action on Malampuzha and Pattambi and the knowledge of senior citizens about the intensity of storm in summer are striking that the velocity of air in contact with the earth surface of basinal area is more, facilitate the evaporation from water surface of the river and the land evaporation from earth surface. Details of evaporation are discussed hereafter in Chapter VII-VI Water Losses.

## **CHAPTER VII**

### **Hydrological Condition**

#### **VII-I Introduction**

Hydrological condition of a region is an important factor of river-alimentation. But, the discernible changes on topography, chainage of vibration on earth surface and the failure of monsoons and summer showers are produced the reduction on quantity of rain water infiltration into the earth. In addition to this, the studies on blockage of sources on the river-head, derivation of deep-most irrigation canals, density of wells in river-bed, density of wells and tanks on land surface, ground water exploitation for construction activities, loss of natural springs and evaporation losses are also dealt in this chapter, with a view to find out the hydrological condition of basinal area.

## **VII-II** Blockage of Sources on River–Head

As shown in Fig No: III-II-I above, there are eleven big dams constructed in different locations on the river-head. Total storing capacity of these dams (Table No: VII-II-I) are 651.61mm<sup>3</sup> of water. In addition to these dams, there are two regulator-cum-dams on the river-bed. They are the Moolathara regulator on the main stream in Kerala -Tamil Nadu boarder and the Cheerakkuzhi regulator in Cheerakkuzhi River, in location on the upper side of the river confluence with the main stream.

The dams are closed immediately after the rainy season. Therefore, the water which can be stored by these dams are being blocked and diverted to the irrigation canals. Besides this, the remaining water on the upper area of the dams are also diverted to the canals by the dams. Hence, the entire water on the upper regions, except the over flows of dams by the particular seasons? are being blocked and diverted through the canals, produced the reduction on sources to the river. Hence, the river is depending only the sources in area from the lower part of the dams.

## **VII-III** Derivation of deep-most Irrigation Canals

The studies about the irrigation canals in North India concluded that, the regional water table has been raised. Whereas, in river-basin it is otherwise. The canals constructed from the dams, dissects the hillocks in number of locations. The deep-most cutting of canals (Fig No: VII-III-I) produced the breakage on water

transit, contained in the hills. Therefore, the water infiltrated into the sub-surface is being charged through the canals. Hence, the relation between the surface drainage and underground drainage are varied. The entire earth of this type is drying up immediately after the monsoons reasoning to dry up the water-course to the river.

#### **VII-IV** Density of wells on the River-bed

In the summer seasons, many streams may be dried with no surface water flows but they may carry appreciable quantity of water as underflows. Depending upon whether the flow is under non-artesian conditions or artesian conditions, it may be classified as underflow channels or underflow conduits (Fig No: VII-IV-I).

In Bharathapuzha, the sources which flow as an underflow channels has been taken by constructing a number of infiltration wells across the river-bed. The chainage system of wells at different locations Fig No: VII-IV-II on river length produced the desiccation before the summer.

#### **VII-V** Density of Wells on Land Surface

##### **VII-V-I** Introduction

In olden days the existing wells and tanks were sufficient to meet the requirements of the people of that time. But, Palakkad became a major industrial centre of Kerala. Secondly, some changes occurred on the family set-up in Kerala. Thirdly, the per-capita demand of water has been increased. Fourthly,

demand of water for agricultural purposes has been increased. Hence, the number of wells and tanks to take water from the earth is increased. Therefore, the increase in per-capita demand of water, growth of dug wells for domestic purposes, growth of industrial wells and growth of agricultural wells. The dug well scheme of minor irrigation and the growth of bore wells are dealt in this chapter.

#### **VII-V-II** Increase on per-capita Demand of Water

The demand for usable water, like any other resources is increasing fast with the continuous increase in population alongwith the continuous increase in per-capita demand, linked with more of sewage disposal, transport and prolific use of water, using gadges (like air cooling and air conditioning devices, washing machine, etc) and increases recreational activities. According to an estimate, the daily per-capita demand for water of an American was 600 gallons in 1900, which increased to 1500 gallons in 1960 and is expected to be increased upto 2700 gallons by the year 2000. This fact is not different in developing world – Ref. Occasional Monograph No: 41 of Indian Institute of Ecology and Environment, New Delhi for the PG Diploma Course in 1992-94. The monograph did not mention the name, who brought out the statement.

#### **VII-V-III** Growth of Wells for Domestic Purposes

Growth of population, conversion of joint family system to the nuclear family life and the influence of Gulf money, etc as described in Chapter No: IV-II-IV and IV-II-V above, results to the growth in number of houses. The system of separate

well for each house is an interesting phenomena of Kerala. By these two aspects, the density of dug wells for domestic purposes is being increased.

The Center for Water Resources Development, Kozhikode carried out a statistics survey about the dug wells used to take ground water for domestic purposes. The survey on 44 samples from all over the three physiographic zone of Kerala indicates that the density of dug wells in coastal belt varies between 90 and 285 wells per sq.km with an average density of about 200 wells per sq.km. In the mid-land region, the density varies between 65 and 245 wells per sq.km with an average density of about 150 wells per sq.km and the density of high land varies between 25 and 197 wells per sq.km with an average density of about 70 wells per sq.km.

As on above, the changes occurred on the joint family set-up, influence of Gulf money and the system of separate well for each house are reasoning to the growth of domestic wells, with the average density of  $200+150+70/3 = 140$  wells per sq.km in Kerala.

#### **VII-V-IV** Growth of Industrial Wells

Demand of water for industrial purposes is quite high. Therefore, to meet the water requirements of the factories, which located near the river bring to consummate their water requirements by taking directly from the river or from the water supply of projects. But, sometimes the quantity of water which gets by

these sources are not sufficient for their requirements. In this circumstance, they are depending the ground water through the dug wells or the bore-wells of their own. Whereas, the factories which are not able to get the river water are fully depending on the underground sources through their wells. Thus the industries give birth to the number of wells on the land surface.

Once the area of Palakkad District was an agrarian land, became a major industrial centre of Kerala. As on Chapter No :IV-II-II above, there are 48 numbers of large and medium industries and 6625 small-scale industries in Palakkad District. Most of them have separate wells to meet their water requirements. Thus the industrial wells in Palakkad District has been increased.

#### **VII-V-V Agricultural Wells**

Demand of water for agriculture is increased by the advent of Green Revolution Policy of Government in 1960. Through this policy the independent India encouraged to convert the fallow lands into agriculture, by providing loans to construct the wells and tanks, results to increase the irrigation scheme of dug well system. But, the area of paddy field in Kerala has been reduced from nine lacks hectares in 1980-81 to 5.5 hectares. But, the cultivation of coconut, pepper, areca, plantain and betal leaf, etc have been increased, results to the over and more demand of water to irrigate them. Secondly, the summer cultivation of

vegetable is the main occupation of poor farmers in rural area. They are depending on the dug wells or the tanks to irrigate them.

As on recordal evidence, 5704 hectares of land has been irrigated by using water from the private tanks and 5719 hectares land has been irrigated by the private wells in Palakkad District – Ref. Source-wise net area irrigated (1985-86) in different District of Kerala Plate No: 27, Water Atlas of Kerala,1995. Hence the number of tanks and wells used to irrigate this area is conceivable and it has been increased in year by year.

**VII-V-VI** Growth in Dug-well Scheme of Minor Irrigation

As on recordal evidence provided from Plate No: 28 (area-wise irrigated by minor irrigation scheme,) Water Atlas of Kerala 1995, the valuable quantity of 10400 hectares land have been irrigated by the dug-well scheme of minor irrigation in Palakkad District. It has been increased in year by year. Hence the influence of dug-wells for the minor irrigation purposes has been increased.

**VII-V-VII** Growth of Bore-wells

Now-a-days, the tendency to construct the artesian wells, (known as bore-wells) has been increased, because it can be constructed within a small area of their house compound. Secondly, this type of wells can be used to take water from the deeper level. Thirdly, construction of bore-well in a house compound is considered as a status in time. By these aspects, density of these types of wells have been increased. Growth of bore-wells construction, which is in the absence of scientific investigation, is reasoning to the depletion of ground water storage.

#### **VII-V-VIII**

##### Ground Water Potential and Utilization

The comparative statement of various agencies about the ground water potential and utilization indicates that the storage of ground water in Kerala is 6732.5 km<sup>3</sup> (average). Out of this, the 1082.5km<sup>3</sup> of water has already been used and the balance of ground water is 5650 km<sup>3</sup>. This has been depleted by the human activities – Ref. Ground Water Potential and Utilization, Plate No: 23, Water Atlas of Kerala.

#### **VII-V-IX**

##### Summary and Conclusion

Increase in per-capita demand of water, growth of population, conversion of joint family system to the nuclear family life, influence of Gulf money as well as the system of separate well for each house are the reasons to derivate the average density of about 140 wells per km<sup>2</sup> for the domestic purposes in Kerala State.

Change of agrarian land into a major industrial centre give birth to 48 numbers of large and medium industries and 6,625 small-scale industries in Palakkad District, produced their own wells to their water requirements.

Encouragements of agriculture by providing loans to construct tanks and wells result to derivate the large number of tanks and wells in Palakkad District. Secondly, the total number of wells required to irrigate 10400 hectares of land through the dug-well scheme of minor irrigation, is constructed by the concerned department of Government. Thirdly, importance of bore-well results to the growth in number of bore-wells in Kerala.

According to the statement by CWR Division, Kozhikode, the storage of ground water in Kerala is  $6732\text{km}^3$  (average). Out of this,  $1082.5\text{ km}^3$  water has already been used. The balance is  $5650\text{km}^3$ . This has been depleted.

It is to be noted that the survey about the wells and tanks conducted by the CWRDM, Kozhikode was before 1995. After this, the quantity in number of wells and tanks have been increased in year by year. Whereas, the quantity of rainfall and the area of rain water infiltration, have been reduced. Hence, the quantity of infiltration has been reduced. The entire water of that area descent into the earth has been extracted through the countless number of wells and tanks. The excessive extraction and the reduction of rain water infiltration into the earth give

rise to the seasonal draught in catchment area and sources region of the river-system, after-effects to desiccate the river before the summer.

#### **VII-VI** Ground Water Exploitation for Construction Activities

Water, the most requisite ingredient, required more in the construction activities, creating problems on ground water resources. It is very difficult to find out the actual quantity of water used in the construction works in a year, because the quantity on usage of water is varied by the size and type of work, time taken to the completion and the season of work conducted. But the Table No: VII-VI-I shows the trend in growth of buildings in rural areas, gives an idea about the quantity of water for construction activities in a year. The bulk quantity of water used for this activity are mostly taken through the wells and tanks is an unaccountable extraction from the earth.

#### **VII-VII** Loss of Natural Springs

Now-a-days, the natural springs which had flowed incessantly are drying up before the summer. Therefore, I had done the direct investigation on a number of cavity springs in Palakkad District. Out of this, the notable

Twenty-five springs in a cluster of ten Panchayaths (Table No: VII-VII-I) are described hereunder.

As on information by the local people, the reason for the loss of five springs in the area of different Panchayaths (Shown in the Table) is the deforestation because once the upper region of these springs had covered by the local forests

of private parties. But, they are give-ground to the rubber plantations, produced the more evaporation losses and reduced the quantity of rainfall infiltration into the earth. At the same time, the other reasons such as the derivation of deep most pumping wells in the crucial point of water transit and human activities to produce the vibrations on the earth crust, etc not identified. Hence the reason suggested by the local people is acceptable.

Location of other eleven springs had no forests. Even then, they were flowed throughout the year of olden days. But, now-a-days, they are being dried up before the summer. In this case, some pumping wells are seen on the water transit of the springs (Fig: VII-VII-I-A). They are interrupting the sources of springs. Secondly, the water which gets in the well are taken by using different sizes of motor pumps produced the desiccation of sources.

Conversion of local forests to the rubber plantations and the derivation of perennial wells on the upper region of the springs are equally responsible to the loss of other three springs.

Reasons for the desiccation of other two springs are not known. Therefore, I think that it may be the force of vibration, by the human activities or by the natural causes are the facts effected in the earth crust.

From the time immemorial, there is no forests or any other vegetative coverage on the location of other four springs. Even then, they have been flowing continuously because; there is no other obstacles on the transit of these springs.

In the absence of scientific evidence, the discernible changes such as the derivation of pumping wells on the crucial point of water transit and the conversion of forest into the rubber plantation are the facts, shows the possibility to the loss of natural springs.

## **CHAPTER VIII**

### **Indiscriminate Action on River-bed**

It is the general opinion that, taking sand from the river-bed is the reason to pollute the river. But, it is not acceptable because the river completed its last stage and it has become practically flat and shallow. Lower part of the river has been completely filled by the deposits and now it is flowing very slowly. But the accidental floods causes erosion of sides. Therefore, taking this deposit from the river-bed is necessary to protect the river from the side erosion and widening through the floods in future.

As on data (Table No: VIII-I) an average of 3,88,918.89mt of sediments have been transported to the sea-ward course in a year. It is exclusive of the quantity of sediments taken by the lorry service and head loads by the human being. If the quantity of sediments left there itself, without taking it will be transported to the sea-ward course by the process of the geological work of running water. It is also noted that, some rivers where no sand is removed, is also dried up immediately after the rainy season. As on reference, in "Mechanism of Microseismic Activity in Kerala – A suggestion" in journal Geological Society of India, April 1996 by Kusala Rajendran and Rajendran, Centre for Earth Science Studies, Thiruvananthapuram, the excessive erosion and over-siltation of river-bed is changing the regional hydro-dynamics. Therefore, if the excessive erosion and over-siltation continued in Bharathapuzha, once it may be a reason for the higher seismogenic potential in its vicinity. According to the above facts, It is clear that sand taking from the river-bed is not a reason to pollute the river,

whereas the indiscriminate action on river-bed is the reason to destroy the purity in originality of the river.

In the upper and the middle part, wherever the river flowing flat, there the sediments like the coarse grained and medium size of sand products are formed in certain height. Instead of cleaning the river by taking the yearly settling deposits of different qualities, the persons who are engaged in profession of sand stripping are taking the products according to their own convenience. It is against the scientific principles of sand drawal. Such a type of activities are resulting to produce the numberless sand-heaps and channels on the river-bed (Photos No: VIII-IA & IB), provides the facilities to the growth of vegetation. The emergence of these articles results to the significant reduction on the quantity of yearly settling products on these locations, because once the river which had flowed in flattish is now concentrated through the channels, subject to expel the sediments to the sea-ward course by the velocity of flowing water, concentrated in the channels. It can be called as Rill-erosion on river-bed. Like that, the vegetation on river-bed would not be allowed to settle the sediments, having lower densities, by the force of water flowing through the articles. Therefore, the medium and fine grain sand are reasoning to expel to the sea-ward course. It is a type of splash erosion on the river-bed. Hence the indiscriminate method of sand drawal reasoning to the rill-erosion and splash erosion, etc on the locations in upper and middle part of the river length, results to expose the rocky layer (Photo No: VIII-

IIA) of earth and withering the river base by the shortage in quantity of deposits to retain the water contents.

Lower part of the river is completely filled with sediments and the river is flowing sluggishly. Instead of cleaning the river-bed by removing the existing sand flats in first, the persons who are engaged in the profession of sand taking concentrated their activities on the sporadic deposits. This irresponsible method of sand stripping produced the diversion on flow of the river, reasoning to uplift more and more sand-hills on the bed which provides facilities to the conversion of these existing sand-flats into mud-flats. The converting mud-flats encouraged the human being to the agriculture and plantation of trees on the locations, resulting to spoil the originality of river.

## **CHAPTER IX**

### **Water Losses**

#### **IX-I Introduction**

Loss of water by evaporation was not felt in olden days. But, now-a-days, it has been producing the seasonal draught on the river-basin. Hence, it is very important to think about it. The facts such as the interception of water by the tar and concrete roads and buildings, evaporation from water surface of the river, land evaporation of the basinal area and the transpiration processes are dealt in this chapter with a view to find out the evaporation losses on the basinal area.

#### **IX-II Interception of Water by Roads and Buildings**

When rain falls, a large quantity of water intercepted by the tar and concrete roads and the buildings, till their surface become completely wet. The interception rate is very high in the beginning of rain, but goes on reducing as the time passes. When the surface become thoroughly wet, then the interception rate falls down. The amount of water required to make these surface completely wet is known as interception storage capacity. The storage quantity of this water completely evaporated to the atmosphere by the temperature and wind. Hence a

large quantity of rain water intercepted by the roads and buildings are losses in a year.

Specified data about the rate of evaporation by the interception of road is not available because it has been varied by the size of vehicles moved on the roads, frequency of the vehicles moved and velocity of its movements. But, as on date (Table No: IV-III-IV-I) above, there are 8006.48 km length of tar and concrete roads in Palakkad District, during the period of 1991-92. It has been increased in year by year. The increasing area of these roads produced more area of interception. Hence, the quantity in loss of water may be increased in year by year because the amount of evaporation is directly proportional to the area of evaporation.

As per the data in Chapter No: IV-II-IV-I above, the density of buildings in Palakkad District is conceivable and it has been increased in day by day. Hence, the area of buildings used to intercept the rainfall has been increased in day by day. Therefore, the quantity of water losses by the interception of buildings may be increased in day by day.

### **IX-III Evaporation from Water Surface**

Evaporation from water surface depends upon the following factors.

They are: -

Depth of Water –Evaporation is much influenced by the depth of water. As the winter starts, the temperature of surrounding air falls, but the temperature of the water in the deep lake and highly flowing river does not fall so easily and thus the water remain warmer than what it would be in a shallow lake or watered river. If the temperature of water is more, the evaporation will be more. Secondly, the temperature of thin film, in contact with water surface, is more than that of the above. The contact film is thus warmer and lighter, easy to disperse and hence more evaporation. It follows that 'increase of depth increases the rate of evaporation in winter season' – Ref : Influence of depth on rate of evaporation, page, 231, Water Losses, Water Resources and Hydrology by Santosh Kumar Garg, 1979 (Third Edition).

In olden days, the river had flowed majestically in winter. But, did not feel the evaporation loss by the abundancy of rainfall. Now, the river has no such a torrential flow after the south-west monsoon. So, there is no chance to the evaporation losses in winter. But, entire flow of the river is concentrated in channels by the human activities produced the depth on its flow, naturally produced more evaporation and it is feeling by the shortage of rainfall.

At the start of summer season, temperature of the entire body of water in shallow lake and watered river, etc will rise and hence normal evaporation will take place. But, on deep lake or highly flowing river the temperature of water will remain much less than that of existing air, which will reduce the evaporation from deep

lake or the highly flowing river because of the following two reasons. They are: (1) when the temperature of water is less, the saturation vapour pressure is less and hence lesser evaporation (Dalton's Law). (2) When the temperature of water is less than that of air above, the film of air in contact with water is colder and, therefore, heavier and more stable and nullifies the effect of wind. The vapours will, therefore, find more difficulty in dispersing and hence reducing evaporation. It is evident from the above discussion that the 'increase of depth reduces the rate of evaporation in summer season'. Ref: Same as above.

According to Bharathapuzha, the entire sources of the river is blocked and diverted through the irrigation canals by constructing eleven numbers of dams or the river-head, results to reduce the depth of flow on the river may be produced more evaporation in summer.

### Area of Evaporation

The amount of evaporation is directly proportional to the area of evaporation. If the exposed area is large, the evaporation will be more and vice-versa. According to Bharathapuzha, the middle and lower parts are having wide area of its bed, may be produced more evaporation. But, in olden days the evaporation did not affect the river as result of prompt supply of rainfalls by the monsoon and summer showers.

### Intensity of Wind on River-bed

The process of evaporation also depends upon the prevailing turbulence in the air. As on Chapter No: VI-IV above, the effect of wind velocity is a peculiarity of Bharathapuzha. Therefore, velocity of the air in contact with the water surface of the river is more. The saturated film of air containing the water vapours will move easily and the diffusion and dispersion of vapour will become easier, causing more evaporation and hence more evaporation losses. But, as a result of the prompt supply of periodical rainfall, the evaporation losses by the velocity of wind on the basinal area was not felt in olden days.

#### **IX-IV** Land Evaporation

Land evaporation is the loss of moisture due to the direct evaporation from the individual soil grains, located at or near the surface. It depends upon the weather condition, topography and structure of earth, type of vegetation and the depth of ground water table.

#### Weather Condition

Temperature and rainfall are the two components of weather. As on Chapter No: VI-II-II above, the temperature on the basinal area has been increased. The increased temperature results to increase the evaporation rate, because if the temperature is more, the saturation vapour pressure increases. Hence, the quantity of evaporation may be increased on the river-basin.

As on Table No: VII-III-IV-I above, the north-east monsoon of India failed to supply the scheduled quantity of rainfall on the central area of the basin. The reduction on rainfall is reasoning to increase the temperature. The increasing temperature naturally produces more evaporation.

### Topography and Structure

As on geomorphology, described in Chapter No: III-VI above, the basinal area of Bharathapuzha is covered by hillocks and small mountains made up of harder, durable and resistible substance of laterite, bed-rocks and the belt of hard-rock. They are exposed in many places by the weathering and erosional damages may result to produce more temperature by its conductivity, manufacturing the evaporation more in rate.

### Depth of Water Table

In Bharathapuzha basin, the ground water is commonly seen within 6 to 10 m depth. The short depth of earth produced more evaporation because the evaporation depends upon the depth of water table. If the water table is high, the land evaporation will be more and if it is lowered the land evaporation will reduce. Hence, the land evaporation may be more in the basinal area. But, did not feel in olden days by the periodical supply of rainfall by the monsoon and summer showers.

### Type of Vegetation

Once the river-basin had a wide area of natural forests. Almost all area of this forest give-ground to the rubber plantations. But, rubber plantation result to produce more evaporation by the reasons as described in Chapter No: IV-VI-IV above. Hence, the change of vegetative cover may result to more evaporation losses.

#### **IX-V** Transpiration

Loss of water by the transpiration of vegetation on terrestrial surface is quite natural. But, by the emergent vegetation on the river-bed (as in Photo No:VIII-IA & VIII-IB before) has been a major factor to think about it. Recordical evidence is not available to find out the quantity of water losses in a year by the emergent vegetation on the river-bed. Secondly, detailed studies are required to justify the facts. By the absence of these two, the facts such as the loss of water by the transpiration of plants in general case and the growth of vegetation on the river-bed are the two facts striking the possibility to the loss of water by the emergent vegetation on the river-bed.

#### **IX-VI** Conclusion

In the absence of scientific facilities to the detailed investigation on the evaporation loss of Bharathapuzha, the factors such as, (1) interception of rainfall on the large area of roads and buildings, (2) evaporation loss from water surface of the river in winter and summer seasons by the water, concentrating through the channels in river-bed, wide area in its middle and lower part of the river

length, intensity of wind on the basinal area, (3) over and more land evaporation by the discernible changes on topography, short depth of water table in the basinal area and (4) transpiration of emergent vegetation on the river-bed are showing the possibility to increase the rate of evaporation on the river-basin, led to the seasonal desiccation of the river.

## **CHAPTER X**

### **Absence of Flood**

In olden days, frequent floods are quite natural in Bharathapuzha by the continuous heavier rainfalls. According to the statement given by the old timers, the tremendous floods occurred in 1990, 1924 and 1941 are most important, which had lasted in number of days. But, from 1941 onwards there are no such

frequent floods as in olden days by the failure of periodical rainfall of monsoons and the blockage of sources by the dams in different location of the same river.

## **CHAPTER XI**

### **Emergence of Vegetation**

Naturally the rivers disperse away the pollutant immediately into the sea-ward course by the current of its flow. Thus, the river becomes free from pollution. But, unfortunately the river has no such a continuous floods as in olden days.

Therefore, the river has reduced and gradually stopped the cyclic processes of the geological work of running water. By the absence of these cyclic processes in a long time, the river becomes filled with the sedimentary deposits and organic materials. These deposits will fill the water volume and soil is formed at the edges and the terrestrial grass becomes established.

The community increases vastly in physical complexity. The surface of bare earth which has shaded differ in light, moisture and humidity. This enables other seeds to grow and new species become established. Woody plants appear again those capable of withstanding disturbed environments and harsh conditions. Hence, some kinds of sedges and shrubs (Photo No :XI –IA) get growing up in the river-bed. These sedges and shrubs first established in the middle part, spread to the other area of the main stream and the tributaries by means of dispersal movements. The inorganic chemical fertilizers, industrial waste, municipal sewages. etc which flowed from the vicinity, provide the nutrients for the growth of these emergent vegetations.

## **CHAPTER XII**

### **Water Condition**

According to the data of water analysis, during the available period of 1987-90, Table No: IX-II-I, the river has no such a menacing water pollution. But, if the processes are allowed to continue like this, a day will definitely come, when we will not be able to find any clear water anywhere in the country.

### **CHAPTER XIII**

## Overall Summary

River Bharathapuzha originates from the Anamudi Peak having a height of 2695 mts MSL in Anamalai hill range in the southern portion of western ghats. It flows 255km length with variable gradient. River system dominated on 6186km<sup>2</sup> on the earth surface. The tall mountains raised on either side of the river length produced the declivity of earth towards the river. The irregularity of earth surface by the isolated mountains and hillocks give-birth to the number of water course to the river. Coverage of earth by the resistive substance of laterite, bed rocks and belt of hard rocks are reasoning to reduce the quantity of rain water infiltration into the earth. Even in such a condition the river flowed continuously throughout the year of olden days. But, now-a-days, it is drying up before the summer.

As on studies, the population growth, industrial and its pertinent developments, urbanization, change of joint family system to the nuclear family life, influence of Gulf money are the reasons to the multiple growth of buildings and roads in Palakkad District. The wide area of shelter by the array of buildings and the wide area of impervious layer of the tar and concrete roads are producing reduction on quantity of rain water infiltration into the earth.

The river-basin had a wide area of natural forests under two heads. They are the reserved forest on hilly tract of mountain belt in side extremities of the river-basin

and the local forests of private parties in central part (plain land of river basin) of the basinal area. But, the major portion of this forest land give-ground to the rubber plantations and some other purposes. Only a few of them are balanced as reserved and vested forests. Deforestation affected mostly on central part of the basinal area, results to the reduction on quantity of rainfall on this region. The forest on hilly tract, except the area of Attapady valley, has no more changes. Hence, there is no more reduction on quantity of rainfall on this area. But, it is my suggestion that, domination of rubber is playing a major role to this desiccation of river.

As a result of perpetual disturbance by the vibrations on the earth surface, due to the human activities and also by the natural cause, the relation between the surface drainage basin and underground drainage basin are varied.

Temperature of Palakkad indicates the dangerous sign, which may lead to the diversion of rainfall by the climatographical changes. According to the rainfall, south-west monsoon of India has no more reduction on its quantity, other than some variations. But, some reduction is indicating on the quantity, by the north-east monsoon and summer showers. Secondly, the quantity of rainfall which gets in central region is very less, when it compared with the quantity of rainfall in side extremities and also very less, when it compared with the basinal average. Like that, intensity of wind on the river basin is a peculiarity of Bharathapuzha; facilitate more evaporation from the water surface of river and the land

evaporation. Hence, the climate of Bharathapuzha shows the unfavorable condition.

According to the hydrological condition, almost all sources of the river have been blocked and diverted through the irrigation canals by constructing eleven numbers of big dams in different locations on the river-head. Hence, the river is depending only on the sources, in area from lower part of dams. Secondly, the canals, which constructed from the dams dissects the hillocks in a number of locations. The deep most cutting of canals results to the breakage on water transit contained in the hills. In such places, the rain water infiltrated into the earth is being discharged to the canals, results to desiccate the area before the summer.

In Bharathapuzha, the sources which flows as an under-flow channels has been taken by constructing a number of infiltration wells across the river-bed, in different locations on river-length, results to the desiccation of river before the summer.

Increasing per capita demand of water, growth in number of wells for the domestic purposes, industrial purposes and irrigation purposes, etc has been increased in year by year. Whereas, the quantity of rain water infiltration into the earth has been reduced. The entire water of that area, descent into the earth has been extracted through the countless number of wells and tanks. The excessive

extraction and the reduction of rain water infiltration into the earth give rise to the seasonal draught in catchment area and the sources region of the river-system. Secondly, water the most requisite ingredient is required more in construction activities. The bulk quantity of these water, used for the uncontrollable growth of construction works are mostly taken through the wells and tanks are the unaccountable extraction from the earth.

It is the general opinion that taking sand from the river-bed is the reason to pollute the river. But, by the absence of scientific evidence, it is not acceptable. Whereas, the indiscriminate method of sand-drawal on the river-bed is against the scientific principles destroying the purity in originality of the river.

Naturally, the rivers disperse away the pollutant immediately into the sea-ward course by the current of its flow. Thus, the river became free from pollution. But, unfortunately, the river has no such a continuous floods as in olden days. Therefore, the river has reduced and gradually stopped the cyclic process of geological work of running water. By the absence of this cyclic process in a long time, the river becomes filled with the sedimentary deposits and organic materials. These deposits filled the water volume and finally soil is formed at the edges and the terrestrial grass becomes established.

The sedges and shrubs first established in the middle of river length spread to the other area and its tributaries by means of dispersal movements. By the

ecological succession, the woody plants are appeared. The inorganic chemical fertilizer, which flowed from the vicinity, provides the nutrients for the growth of these emergent vegetations. But, on the water analysis the river has no such a type of menacing water pollution.

## **CHAPTER XIV**

### **Conclusion**

A detailed investigation alongwith a number of parameters is required to justify the facts. But, I could not dominate it by the limitation. Even then, the findings, which emerged from the analysis of available data, it is clear that the “Environmental problem on Water Resources of the River-system” is a reason, which destroys the purity in originality of the river. Therefore, she could not serve any purpose for which a river is meant. According to the data of water analysis, the river has no such a menacing water pollution. The pollution affected on the body of the river. So, it can be called or named as “River Pollution”. Secondly, till the time there is no such a pollution on the body of any river other than water pollution. Therefore, river pollution is a new and growing chapter in the subject of Environmental Science.

The birth, growth and death are the law of nature. The death of a culture gives birth to a new culture. If it is through the natural process, it is more effective and realizable. But, if it is through the man-made process it will be harmful, less effective and unrealizable and artificial. This leads to the displacement of the

balance of nature and that is what is happening here. Therefore, it is an immediate need to take the effective measures to protect the river.

## **CHAPTER XV**

### **Suggestion**

#### **XV - I** Ganga Action Plan and Bharathapuzha

According to the Ganga Action Plan 1985, the cleaning of Ganga is started in two phases. In the first phase, cleaning of the basin of Ganga only. In the second phase, cleaning of the tributaries of Ganga. This plan is also going to be merged with the national river action plan, which deals with the cleaning of the rivers of India. Therefore, it will take time to get the benefits of the Action Plan in or for our river. But, before getting such a benefits, she may die with the river pollution, “a cankerous decease”, because it is more dangerous than water pollution. Therefore, priority must be given to the river pollution because the question of water pollution arises only on the flowing rivers.

#### **XV-II** India's Response to Environmental Challenges

The Constitution of Independent India has recognized the importance of environmental protection. It has been stressed in the Directive Principles of the

Constitution of India. By the Article 48-A, it is stipulated, “the State shall endeavor to protect and improve the environment and to safeguard the forest and wild life of the country”. The Article 51-A(G) lays down that “it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures”.

While inaugurating the thirteenth Commissioners’ Conference in New Delhi a few years ago, our late Indian Prime Minister Mrs. Indira Gandhi agreed that “Industrialization has brought air and water pollution. The wild life and flora and fauna have to be saved. A new awakening has come about these aspects”. Then, why not to accelerate this program of preventing the river pollution with full vigor and zeal from today onwards.

## **CHAPTER XVI**

### **Protective Measures**

Conservation of river is a crying need, but development and pollution control are equally important. Therefore, in future all the development programs must be drawn out by anticipation of preservation. It can be achieved by the following measures. But, the environmental knowledge of the people and the active and sincere co-operation are most essential.

Before conserving the river, we must have to conserve the basinal area of that river in first, because river alimentation is controlled by the geomorphic, climate and hydrologic condition of that region. Therefore, it is necessary to reduce the exploitation activities on forest and increase the area of vegetational coverage. For this, better way is the Green Policy.

Reduce the indiscriminative method of mining activities, rock blasting in wells and the usage of high power explosives in fire works, etc to reduce the perpetual disturbance in earth, which will help to protect the earth from loosing of the natural compactness of soil in that region and loss of water.

In order to reduce the acceleration of ground water discharge by the irregularity of earth surface, construct the check dams and sub-surface dams in valleys and water-way on the basinal area. It will help to the long-lasting sources on that region. For storing the excess water flowing through the river, construct a number of reservoirs or sub-surface dams at suitable places.

To bring back the originality of river, it is better to adopt the scientific system of sand-drawal on river-beds under the control of experts in this field. The better way of sand taking is the project of sand-mining on river-bed.

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**Table No:- IV-II-II-I**  
**Growth rate of S.S.I. units in Palakkad**

SI No	Year	<u>Number of Units</u>	Total number of units	<u>Growth rate</u>
I	Upto 1983-84	-----	1524	-----
II	1983-84	203	1724	13.30
III	1984-85	216	1943	12.50
IV	1985-86	336	2279	17.30
V	1986-87	400	2679	17.55
VI	1987-88	576	3255	21.50
VII	1988-89	750	4005	23.04
VIII	1989-90	402	4407	10.03
IX	1990-91	608	5015	13.80
X	1991-92	760	5775	15.15
XI	1992-93	750	6525	12.99

**Source:** Table No- 5-2 (6) Chapter NO:- V  
Industrial Potential Survey, Palakkad

**Table No: IV-II-III-I**

**Data of Institutional Buildings pertaining to the industrial growth in Palakkad**

Sl No	Category of Institutions	Numbers in Districts
I	Animal Husbandry	123
II	Electrical Substations	31
III	K.S.R.T. Units	4
IV	Telephone Exchanges	63
V	Post Offices	442
VI	Bank Buildings	372
VII	Educational Institutions	800
VIII	Medical Institutions	180
	Total	2015

**Source:** Report on Industrial Potential Survey in

Palakkad, Pages 29 to 56

**Table No: IV-II-V-I**

Classification on R.C.C Building Owners

		Profession of Building owners	
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Sl. No	Name of Panchayath	Gulf Employees	Working in Public Sector	Working in Private Sector	Own Business	Agriculture	Total Buildings
I	Lekkidi-Perur	15	8	5	4	2	34
II	Mannur	12	6	4	6	3	31
III	Mankarai	8	5	6	2	3	24
IV	Parli	6	4	5	2	4	21
V	Mundur	7	4	2	3	5	21
VI	Kongad	6	6	3	4	5	24
VII	Keralassery	9	3	2	3	4	21
VIII	Kadambazhippuram	5	5	6	2	4	22
IX	Vellineshi	4	5	4	5	3	21
X	Ambalapara	8	4	8	4	2	26
		80	50	45	35	35	245

**Table No: IV-II-VI-I**

**Density of Buildings in a cluster of seven Panchayaths**

**As on 01/01/2000**

	Name of Panchayath	Area of Panchayath in km <sup>2</sup>	Number of Buildings	Density of buildings in km <sup>2</sup>
I	Lakkidi-Perur	30.379	7014	231
II	Mankara	20.53	4420	215
III	Kottay	19.865	3658	184

IV	Vaniamkulam	35.52	8032	226
V	Keralassery	23.95	3768	157
VI	Kongad	35.55	7164	202
VII	Mannur	18.51	4702	254
	Total	184.306	38758	-
	Average			
	210			

**Source:** Panchayaths Concerned

**Table No: IV-III-IV-I**

SI No.	Classification	Road length (Km)	
		District	State
1	National High way	70.00	1011.00
2	Roads under P.W.D -		
a	State High way	143.507	1890.35
b	Major District Roads	748.925	6010.252
c	Other District Roads	199.710	9556.762
d	Village Roads	199.710	2956.570
3	Roads under local bodies	6380.000	10,1067.000
	Total	8006.482	

1,22,491.935

**Source:** Table No 43 chapter IV. Distribution of roads in Report on Industrial Potential Survey, Palakkad – other Economic Review – 1992, Sate Planning Board, Govt. of Kerala.

**Table No: IV-V-III-I**

**Area of reserved forest and proposed for reservation in Palakkad**  
**As on 30<sup>th</sup> June 1913**

SI No:	Taluk	Reserved forest in ACS	Area Proposed for Reservation in ACS	Total in ACS
I	Valluvanadu	51491.4	22502.00	73993.4
II	Palakkad	35818.00	-----	35818.00
	Total	87309.4	22502.00	109811.4 or 44440 ha

**Source:** Table No: X, Statistical Appendix for Malabar, Volume No: II, Malabar Gazette, by C.A. Innes, ICS 1997

area cited in the Table is after converting from Sqm to ACS

**Table No: IV-V-III-II**

**Particulars of Forest Area - 1991**

SI No	Type of Forest	Area in Ha
I	Reserved Forest	48749
II	Proposed for Reservation of Forest	-----
III	Vested Forest	75149
Total		123928

Industrial Potential  
Review -1992 State

**Source:** Chapter No: 3-9-1, Forest Cover,  
Survey in Palakkad, after Economic  
Planning Board, Govt. of Kerala.

**Table No: IV-V-V-I**

**Area-wise Rainfall (Based on 24 Selected Stations) on Bharathapuzha**

SI No	Classification of Locations	Year of Rainfall in mm				
		1989	1990	1991	1992	Total
I	South extremity	2355.5	2522	2665.66	3131	2668.5

	(Based on six locations available)					
II	North extremity (Based on four locations)	2090	1937.75	2377.75	2811.25	2304.187
III	Central area (Based on ten locations)	1362.3	1507.9	1777.5	1955.5	1631.5
IV	Lower part (Based on four locations)	2102.75	2449.00	3003.00	2965.5	2630.125

**Source:** KERI, Peechi, Thrissur District, Kerala State.

**Table No: V-II-I**

**Propagation Velocity of Longitudinal waves through even categories of soil**

Sl. No	Soil Categories	Vn/ Kms <sup>-1</sup>	Vo Po / Vn Pn	$\Delta I$	
				From Eq (11.9)	From Experiment
1	Granites	5.6	1.0	0	0
2	Limestone and Sandstone	4.5-2.5	1.3-3.2	0.2-0.85	0-1
3	Half rocks (Gypsum & Marls)	3.0-1.7	2.3-5.6	0.58-1.2	1
4	Fragmental rocks (rock debris, gravel, pebble)	2.1-0.9	3.9-11.5	1.1-1.74	1-2
5	Sands	1.6-0.6	5.2-16.2	1.2-2.0	1-2
6	Clay Soils (Clays,	1.5-0.6	5.4-16.2	1.2-2.0	1-2

	Loams, Sandy loams)				
7	Loose fill up soils	0.6-0.2	20.2-60.0	2.2-3.0	2-3

- Notes:** -(1) Eq No-11.9 =  $\Delta I = 1.69 [\lg (V_o P_o) - \lg (V_n P_n)]$   
(2) The data are given for soils with medium moisture content  
(3)  $V_n$  is the propagation velocity of longitudinal waves

**Source:** Ch. II.4 - Effect of soil condition on earthquake intensity,  
Design of Earthquake Resistant Structures, by S.V. Polyakov

**Table No: V-V-I**  
**Earthquakes in association with Bharathapuzha**

Sl No	Year	Location	Magnitude/ Intensity
1	24/06/1865	Near Coimbatore	4
2	28/02/1900	"	7
3	29/07/1972	"	6
4	1981-1993	Central part of Palakkad Gap	1-2
5	15/03/1989	Near Vadakkanchery	3
6	26/02/1993	"	3.6
7	02/12/1994	"	4.3
8	26/02/1996	"	3.0
9	06/09/1996	Thrissur	3.0

**Source:** Research Communication Vol. 70 of  
February 1996 and the paper  
03/02/2001  
publication in Mathrubhumi Daily dated

**Table No: VI-II-I**  
**Temperature in Cochin and Calicut Taluks of Old Malabar during British**  
**Rule**

Sl. No	Months	Cochin (Average)		Mean	Calicut (Average)		Mean
		Max	Min		Max	Min	
1	January	89.1	71.5	80.3	87.6	69.6	78.6
2	February	89.9	73.7	81.8	88.7	72.6	80.7
3	March	91.2	77.0	84.1	90.3	76.1	83.2
4	April	91.5	78.4	85.0	91.3	77.9	84.6
5	May	89.6	77.6	83.6	90.4	77.9	84.1
6	June	85.0	74.7	79.8	84.6	74.7	79.7
7	July	83.5	71.1	78.8	82.5	73.9	78.2
8	August	83.7	74.3	79.0	82.8	74.1	78.4
9	September	84.6	74.5	79.6	84.3	74.4	79.3
10	October	86.2	74.6	80.4	86.2	74.5	80.4
11	November	87.5	74.4	80.9	87.4	73.1	80.2
12	December	88.5	72.9	80.7	87.6	70.5	79.1
13	The Year	87.55	74.8	81.2	86.9	74.1	80.5

**Source:** Chapter No: I, Climate, Malabar Gazetter by C.A. Innes, I.C.S

**Table No: VI-II-II-I**  
**Mean Temperature of Palakkad and Malampuzha (1993 – 99)**

Sl No	Year	Palakkad				Malampuzha			
		Maximum		Minimum		Maximum		Minimum	
		Month	Temperature	Month	Temperature	Month	Temperature	Month	Temperature
I	1993	April	40.6 <sup>0</sup> C	June	25.4 <sup>0</sup> C	April	40.0 <sup>0</sup> C	January	
II	1994	March	39.4 <sup>0</sup> C	July	25.2 <sup>0</sup> C	April	38.9 <sup>0</sup> C	December	
III	1995	April	39.4 <sup>0</sup> C	July	24.8 <sup>0</sup> C	April	38.9 <sup>0</sup> C	January	
IV	1996	March	40.00 <sup>0</sup> C	June	23.8 <sup>0</sup> C	April	38.9 <sup>0</sup> C	November	
V	1997	March	38.00 <sup>0</sup> C	July	23.8 <sup>0</sup> C	March	38.3 <sup>0</sup> C	February	
VI	1998	May	40.00 <sup>0</sup> C	June	32.2 <sup>0</sup> C	April	39.4 <sup>0</sup> C	January	
VII	1999	February	38.6 <sup>0</sup> C	July	24.00 <sup>0</sup> C	March	38.3 <sup>0</sup> C	January	
		Average	39.4 <sup>0</sup> C		24.31 <sup>0</sup> C		38.9 <sup>0</sup> C		

**Source :** Temperature Register Office of the Taluk Tahsildar, Palakkad and Office of the Asst. Executive Engineer, Dam Division, Malampuzha dated: 24/1/2000.

**Table No: VI-III-I-I**

**Annual Rainfall and Stream flow of selected twenty rivers in Kerala**

Sl No	Name of River	Basin Area	Average Annual Rainfall	Average Annual Stream Flow	Sl No	Name of River	Basin Area	Average Annual Rainfall	Average Annual Stream Flow
		KM2	mm	Mm3			Km2	mm	mm3
I	Shiriya	587	3700	1415.5	XI	Chalakkudy	1074	3600	1629
II	Chandragiri	1406	4000	3964	XII	Periyar	5398	3200	4867
III	Kariangod	1122	3600	1356	XIII	Muvattupuzha	1554	3100	356.6
IV	Kuppam	539	3800	1516	XIV	Meenachil	1272	3000	1059
V	Valapattanam	1867	3600	4779	XV	Manimala	1847	3300	1560
VI	Kuttiyadi	583	4500	1273.5	XVI	Pamba	2235	3600	3423

VII	Chaliyar	2923	3800	5902	XVII	Achancoil	1484	2600	1484
VIII	Kadalundi	1122	3400	1137.3	XVIII	Kallada Group	1699	2800	3374
IX	Bharathapuzha	6186	2300	5082.9	XIX	Vamanapuram	867	2200	1324
X	Karuvannur	1054	3200	1398.3	XX	Kabbini	1920	3600	2413

**Source:** Water Atlas of Kerala, Plate No: 34 to 58

**Table No: VI-III-I-II**

**Mean Annual Rainy Days at Ponnani, Mannarkad and Palakkad, on  
Bharathapuzha Basin**

Sl No	Place	South-West Monsoon , June to Sep		North-east Monsoon Oct-Dec		Other than Monsoon Jan-May		Total Rainy Days	Percentage
		Days	Percentage %	Days	Percentage %	Days	Percentage %		
1	Ponnani	79	62.7	23	18.3	24	19	126	100%
2	Mannarkad	77	62.00	25	20.2	22	17.7	124	100%
3	Palakkad	69	65.7	20	19.5	16	15.3	105	100%
	Average	75	63.5	22	19.17	21	17.33	118	100%

**Source :** Plate No: 8, Mean Annual Rainy Days , Water Atlas of Kerala , 1995

**Table No: VII-III-II-I**

Annual Rainfall on Bharathapuzha basin  
during the period of 1979-1992

SI No	Year	Rainfall mm	SI No	Year	Rainfall mm
1	1979	2478	8	1986	1823
2	1980	2561	9	1987	1693
3	1981	2679	10	1988	1929
4	1982	1837	11	1989	1822
5	1983	1972	12	1990	1990
6	1984	1931	13	1991	2278
7	1985	2066	14	1992	2560

**Source:** Kerala Engineering Research Institute,  
Peechi,  
Thirussur (Dist), Kerala State

**Table No: VI-III-III-I**

Comparison of Rainfall of the years 1901-1909 with 1979-1992

SI No	Station	Year 1901- 1909	Quantity in mm	Year 1979-1992	Quantity in mm	Variation In mm	
						+ve	-ve
I	Mannarkad	1901-	2999	1979-1992	2189	-	810

		1909		(14 years)			
II	Ottapalam	1901-1909	2508	1979-1992	2282	-	226
III	Parli	1901-1909	2567	10 years	2911	344	-
IV	Alathur	1907-1909	2430	10 years	1861	-	569
V	Palakkad	1907-1909	1991	13 years	1902	-	89

**Note:-** Parli, Alathur and Palakkad, did not maintain the records properly. Therefore, the available periods which get from 1979-92 is as in the table.

**Source:-** Table No: XII, Volume II, Malabar Gazetteer by C.A. Innes, ICS 1997 and annual rainfall on Bharathapuzha basin during 1979-92, Kerala Engineering Research Institute, Peechi, Thrissur District, Kerala

**Table No: VI-III-IV-I**

**Variation of season-wise rainfall on Bharathapuzha basin, based on 24 stations, during 1989-92**

SI No	Year	S-Water Monsoon in mm				N-E Monsoon in mm				Summer Shower in mm			
		A	B	C		A	B	C		A	B	C	
				+ve	-ve			+ve	-ve			+ve	-ve
I	1989	1394	1460.5	-	66.5	266	440.91	-	147.91	162	398.59	-	236.39
II	1990	1249	"	-	211.5	358	"	-	82.91	383	"	-	15.59
III	1991	1840	"	379.5	-	295	"	-	145.91	143	"	-	225.59

IV	1992	1937	“	531.5	-	407	“	-	33.9	216	“	-	182.59
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**Note:** I) A is the received quantity of rainfall  
 II) B is the quantity, which had to be obtained at the rate of 63.5% of 2300mm rainfall  
 III) C is the variation in more (+ve) or less (-ve) level.

**Source:** Kerala Engineering Research Institute, Thrissur District, Kerala.

**Table No: VI-III-V-I**  
**Area-wise rainfall (based on 24 selected locations)**

Sl No	Classification of Area	Quantity of rainfall in mm				Average in mm
		1989	1990	1991	1992	
I	Hilly tract on south extremity of river basin based on six locations	2355.5	2522	2665.66	3131	2668.5
II	Hilly tract on North side based on four locations	2090	1937.75	2377.75	2811.25	2304.187
III	Plain of basin area based on ten locations	1362.3	1507.9	1777.5	1555.5	1631.5
IV	Lower part of basinal area based on four locations	2102.75	2449	3003	2965.5	2630.125

**Source :** Kerala Engineering Research Institute, Peechi, Thrissur

District , Kerala

**Table No: VI-IV-I**

**Mean wind speed on Malampuzha and Pattambi**

Months	1990				1991				1992			
	Malampuzha		Pattambi		Malampuzha		Pattambi		Malampuzha		Pattambi	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	Km/H		Km/H		Km/H		Km/H		Km/H		Km/H	
January	24.288	0.112	13.7	2.7	26.3	-	15.4	1.6	38.44	-	13.2	
February	25.988	5.712	14.00	3.7	22.55	-	11.1	1.6	21.53	-	6.6	
March	10.53	2.86	9.5	3.7	12.41	-	9.8	2.3	22.06	-	5.8	
April	2.88	4.496	6.9	4.0	10.88	-	6.3	2.7	14.81	-	7.4	
May	8.448	4.88	6.1	2.3	15.70	-	5.5	1.3	13.84	-	6.1	
June	11.008	4.144	4.7	1.4	11.85	-	7.1	0.5	27.93	-	7.4	
July	10.00	3.8	4.8	2.3	14.43	-	5.6	1.8	23.34	-	7.2	
August	11.136	4.928	7.9	2.7	12.78	-	6.6	1.6	16.94	-	7.6	
September	11.184	5.648	8.7	1.6	11.15	-	6.4	1.8	17.04	-	5.00	
October	9.776	2.624	6.4	1.1	11.55	-	6.3	1.1	12.08	-	3.1	
November	16.800	2.065	7.7	1.00	22.20	-	11.4	0.8	27.32	-	8.00	
December	22.336	3.312	14.3	2.1	28.03	-	15.00	1.4	55.43	-	14.00	
Mean	13.697	3.715	8.725	2.38	16.44	-	8.875	1.541	24.23	-	7.61	

**Source :** Field Studies Circle, Irrigation Complex, Thrissur, Kerala Dated  
29/03/2000

**Table No: VII-II-I**

**Details of Dams on Bharathapuzha basin**

SI No	Name of Dams	Location in State	Catchment area in km <sup>2</sup>	Quantity of water storable in Million m <sup>3</sup>
I	Upper Aliyar Dam	Tamil Nadu	140.52	26.55
II	Aliyar Dam	Tamil Nadu	196.89	109.35
III	Thirumurthy Dam	Tamil Nadu	80.31	46.05
IV	Attapady Project	Kerala	43.20	60.73
V	Kanhirapuzh Dam	Kerala	70.00	60.00
VI	Malampuzha Dam	Kerala	147.60	226.00
VII	Pothundi Dam	Kerala	31.00	50.91
VIII	Meenkara or Gayathri Dam	Kerala	90.65	12.75
IX	Chulliyar Dam	Kerala	29.78	13.70
X	Mangalam Dam	Kerala	48.85	25.50
XI	Walayar Dam	Kerala	106.37	20.08
XII	Moolathara Regulator	Kerala	-	9.769
XIII	Cheerakkuzhi Regulator	Kerala	-	-

**Source :** Office concerned of the Dams

**Table No: VII-VI-I**  
**Trend in growth of buildings in a year on selected**  
**Grama Panchayaths during 1980-90 in**  
**rural area of**  
**Palakkad District**

Sl.No.	Name of Panchayath	Growth rate on One 1 Km <sup>2</sup>
1	Mannur	5.83
2	Lekkidi	3.605

3	Kongad	3.38
4	Mankarai	6.48
5	Vanikyamkulam Average	<u>4.56</u> <u>4.77</u>
	or say 5 buildings/ Km <sup>2</sup> in a year	

**Source :** Panchayaths concerned.

**Table No: VII-VII-I**

**Loosing of springs in a cluster of 10 Panchayaths in Palakkad District**

Sl No	Name of Panchayath	Reasons					Total
		I Deforestation	II Derivation of wells	III Both I & II	IV Other Reasons	V Flowing wells	
I	Lakkidi	-	1	-	-	1	2
II	Mannur	-	1	1	-	1	3
III	Mankara	-	1	-	1	-	2
IV	Mundur	1	1	1	-	-	3
V	Keralassery	1	1	-	1	-	3
VI	Kongad	1	1	1	-	-	3
VII	Kadambazhipuram	1	2	-	-	-	3
VIII	Parli	-	1	-	-	2	3
IX	Pookotu Kalikave	1	1	-	-	-	2

X	Ambalapara	-	1	-	-	-	1
Total		5	11	3	2	4	25

**Table No: VIII-I**  
**Data of sediments transportal through the Kumbidi Observatory in**  
**Bharathapuzha**

SI No	Years	Course grain sand	Medium Sand	Fire Grain Sand	Total in Metrickion
I	1981-82	51457	71131	721181	843859
II	1982-83	18430	30241	313906	362577
III	1983-84	17857	30939	267927	3167231
IV	1984-85	37298	45239	361843	444380
V	1985-86	40738	63293	339753	4443784
VI	1986-87	26463	47960	281491	355914
VII	1987-88	1135	2431	151250	154816
VIII	1988-89	5887	10134	260765	2767.86
IX	1989-80	8335	15224	277872	301431
	Average	23076.67	35176.89	330665.33	3,88,918.89

**Source :** Central Water Commission, South Western River Division, Cochin, Kerala state dated 29/12/1993

**Table No: IX-II-I**

**River Water Analysis. Location- Kumbidi**

River : Bharathapuzha

Catchment Area: 5755 sq. k.m.,

W:year -1987-1990

.tb 5 #23 #31 #40 #47 #56 #63

Sl No	Parameters	1987-88 Jun-May		1988-89 Jun-Feb		1989-90 Jul-Feb	
		Max	Min	Max	Min	Max	Min
1	<u>PHYSICAL</u>	206.16	197.2	308.8	4.37	407.6	4.80
	Quantity (Cumec)						
	Temp. (oC)	31.00	24.5	32.00	25.5	29.5	26.00
	P.H.	6.65 to	8.12	7.2 to	8.16	6.68 to	8.17
	Sp. Conductnace (Micromhos/ cm)	280.00	74.00	231.00	88.00	177.00	81.00
2	<u>CHEMICAL</u>	0.09	0.02	0.06	0.03	0.09	0.02
	K+						
	Na+	0.83	0.13	0.49	0.23	0.45	0.20
	Ca++	3.12	0.45	1.86	0.64	0.72	0.32
	Mg++	2.23	0.50	2.28	0.32	0.56	0.70
	Cationic Total	8.20	1.10	4.40	1.28	1.64	1.02
	Hco3	1.52	0.38	1.32	0.20	1.45	0.53
	C1.	0.88	0.37	0.81	0.54	0.60	0.44
	F, So4, So3	--	--	--	--	--	--
	No2, Po4, Slo3	--	--	--	--	--	--
	Anionc Total	2.54	0.75	3.79	1.14	2.10	0.73

**Source : Central Water Commission**

**Table No: IX-II-I**

**River Water Analysis Location- Kumbidi**

River: Bharathapuzha

Catchment Area – 5755 sq.km

W-Year – 1987-1990

Sl No	Parameters	1987-88 Jun-May		1988-89 Jun-Feb		1989-90 Jul-Feb	
		Max	Min	Max	Min	Max	Min
3	BIOLOGICAL &	--	--	--	--	--	--

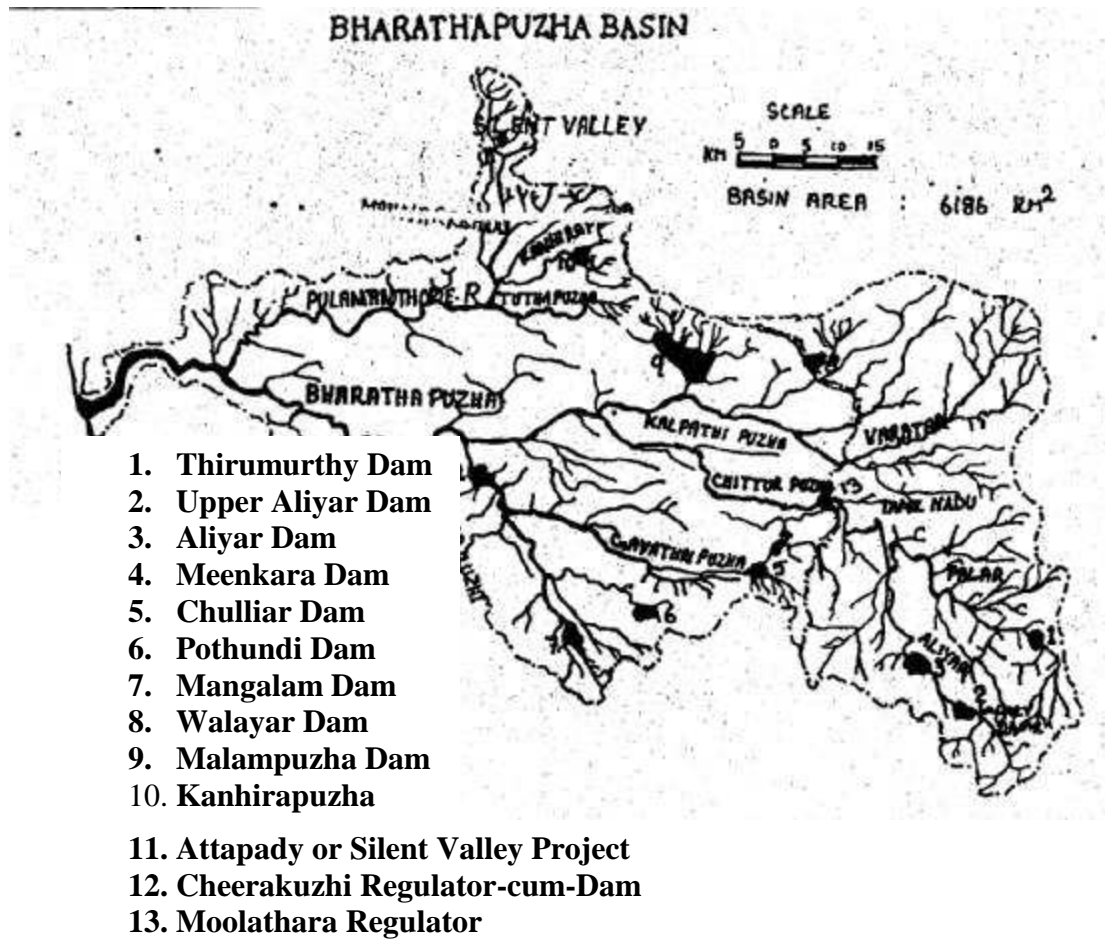
	BACTERIOLOGICAL						
4	TRACE & TOXIC	--	--	--	--	--	--
5	CHEMICAL INDICES	364.00	55.00	199.00	48.00	58.08	36.05
	Hardness No						
	Sodium %ge	14.58	80.00	25.93	7.82	27.44	19.61
	SAR	0.44	0.15	0.59	0.23	0.59	0.23
	RSC	Nil	Nil	Nil	Nil	Nil	Nil
	Classification	C1 S1	C1 S1	C1 S1	C1 S1	C1 S1	C1 S1

- Note:** (1) (-) Indicated that analysis of a particular parameter has not been carried out
- (2) All the Ionic concentrations are expressed in me/l
- (3) When concentration is negligible, it is presumed to be of NIL value and so indicated
- (4) + Indicates estimated discharge
- (5) After February the river is drying up

**Source:** Central Water Commission, South-Western River Division, Cochin, Kerala dated 29/12/1993

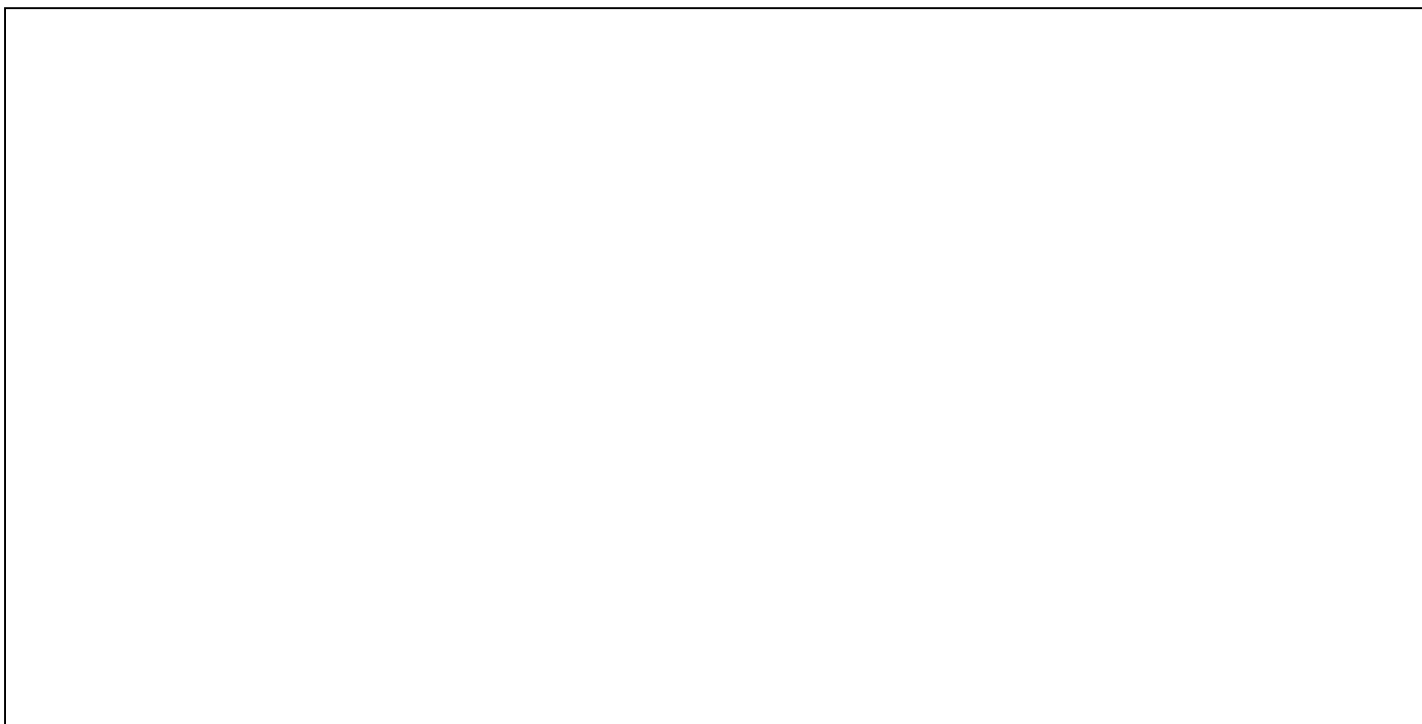
**Fig No: III-II-I**

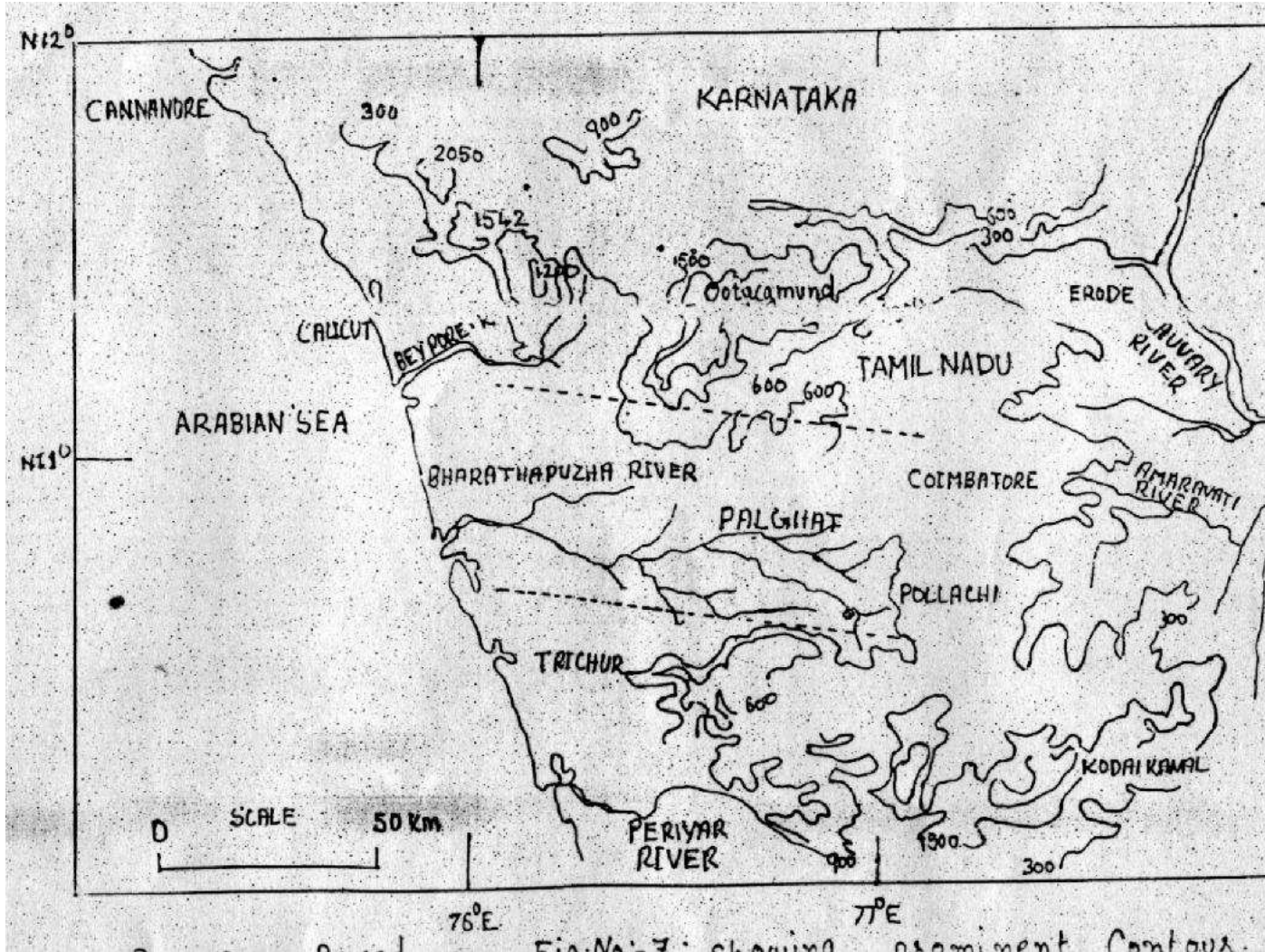




Source: Bharathapuzha Basin Plate No 43, Water Atlas of Kerala, 1995

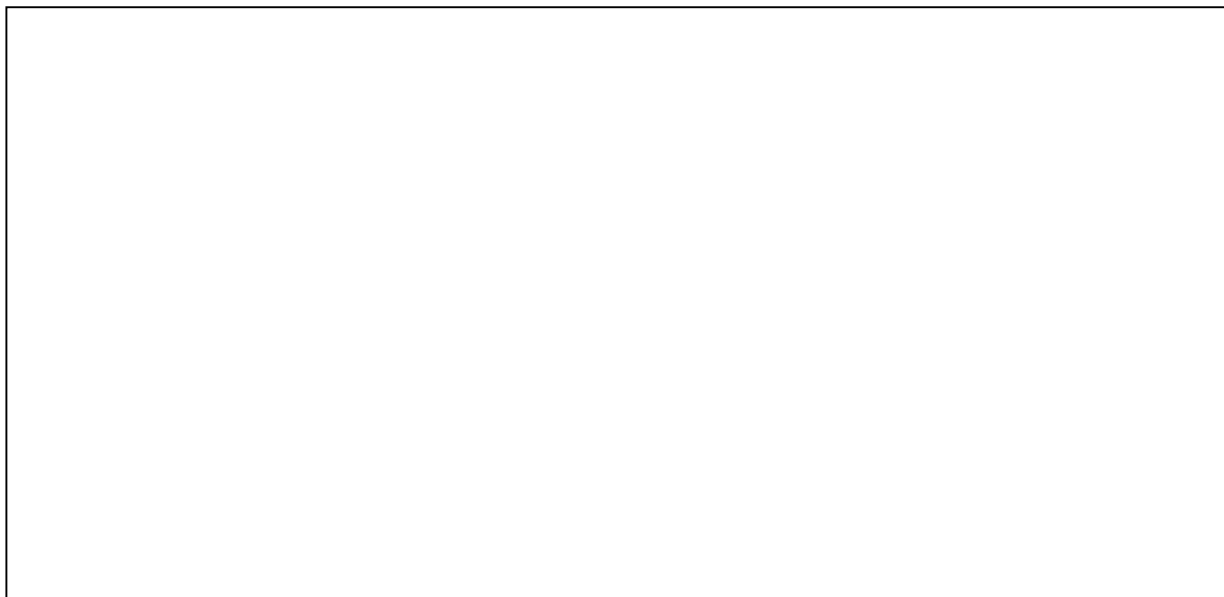
**Fig No: III-II-II,  
Aproximate Length of Palakkad Gap**





Source : Based on upon Fig No:-7; showing prominent Contour 'A Report on the December 2, 1994, Wadakkanchery Earth Quake, Centre for Earth Science Studies, Thiruvanahtnapuram. Dashed lines mark the approximate extent of the Palakkad Gap by the tall mountains.

Fig No:- III-III-I



HYDROLOGIC SURVEY

Hydraulic Gradient of Bharathapuzha taken from Physical Map, India, Palakkad

S.L.No	NAME OF PLACES
1	PONNANI SEA LEVEL
2	KUTTIPURAM
3	THUTHA PUZHA JUNCTION
4	THRITHALA
5	PATTAMBI
6	SHORNUR
7	CHEERAKUZZHI RIVER JUNCTION
8	MANKARA OBSERVATION CENTRE
9	KALPATHI PUZHA JUNCTION
10	KANNADI BRIDGE IN PALAKKAD
11	SOUTH CHITTUR
12	STATE BORDER

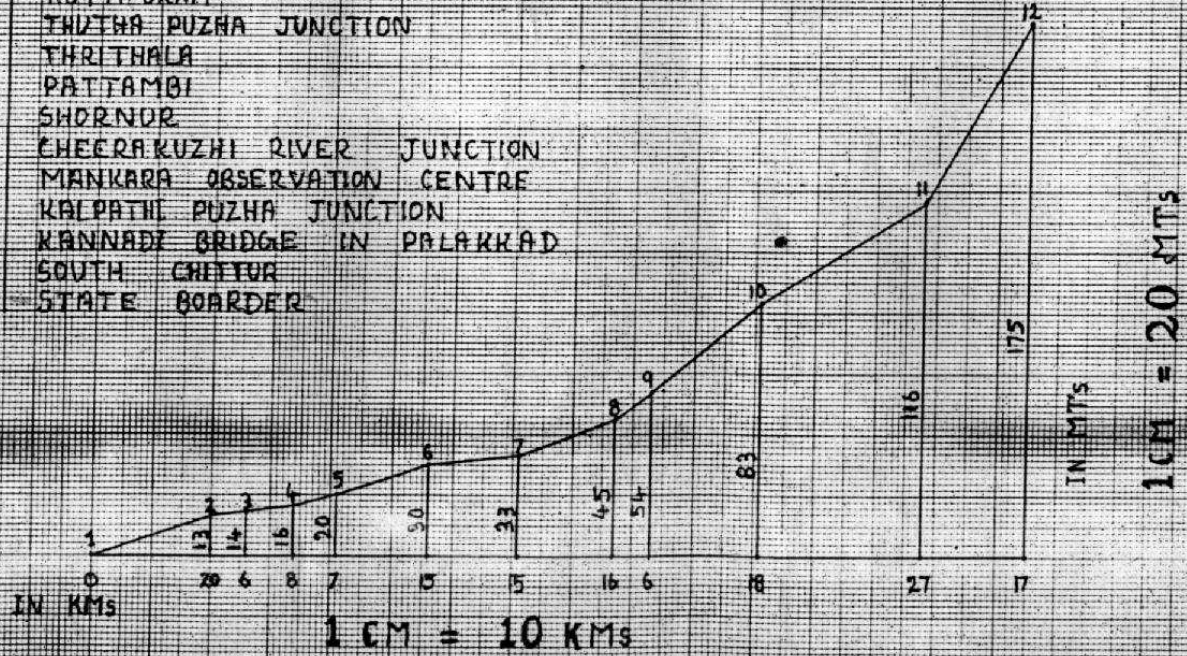
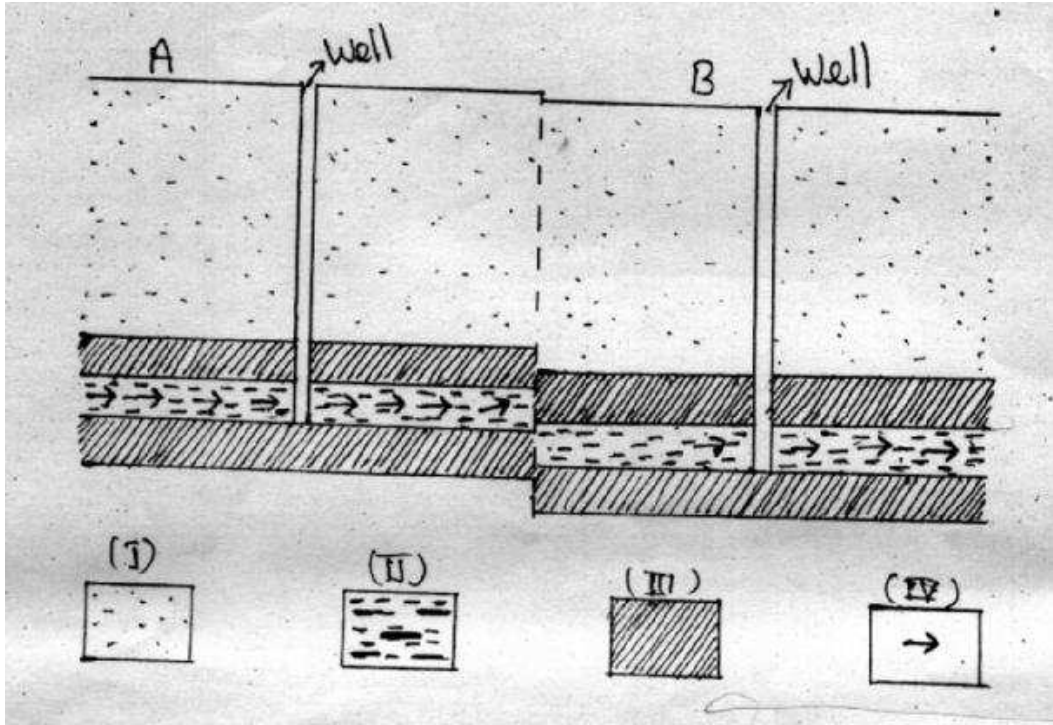


Fig No: V-IV-I

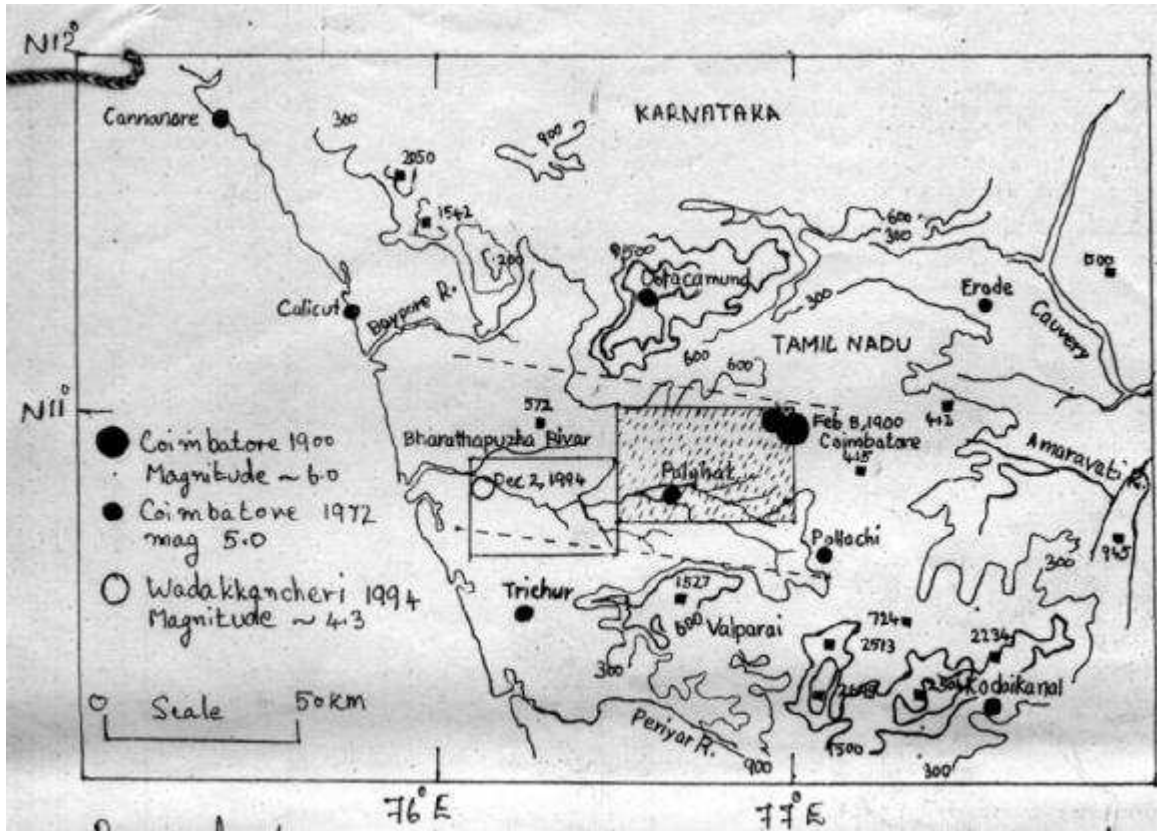
Diagram showing blockage on Water-ways by the faults



A is the existing part of layer  
 B is the slipped block

I :- Dry earth, II :- Water bearing rock,  
 III :- Impervious rock, IV :- Water flow direction

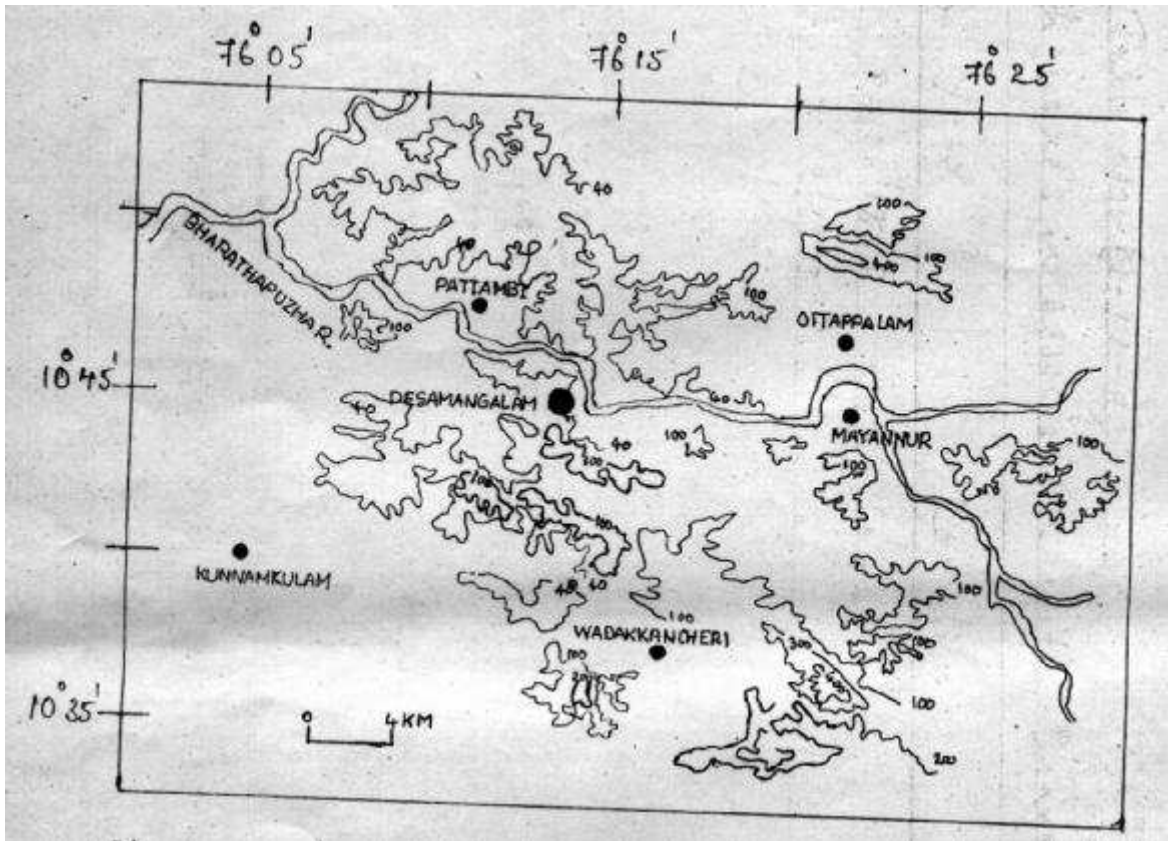
Fig No: V-V-I



**Regional Physiographic map showing the prominent contours. Dashed lines mark the approximate extent of the Palakkad Gap. Sites of notable earthquakes from the area are indicated. Shaded area indicates region of microseismic activity recorded by GBA.**

**Source : A report on the December 2, 1994 Wadakkanchery earthquake, by Centre for Earth Science Studies**

Fig No: V-V-II

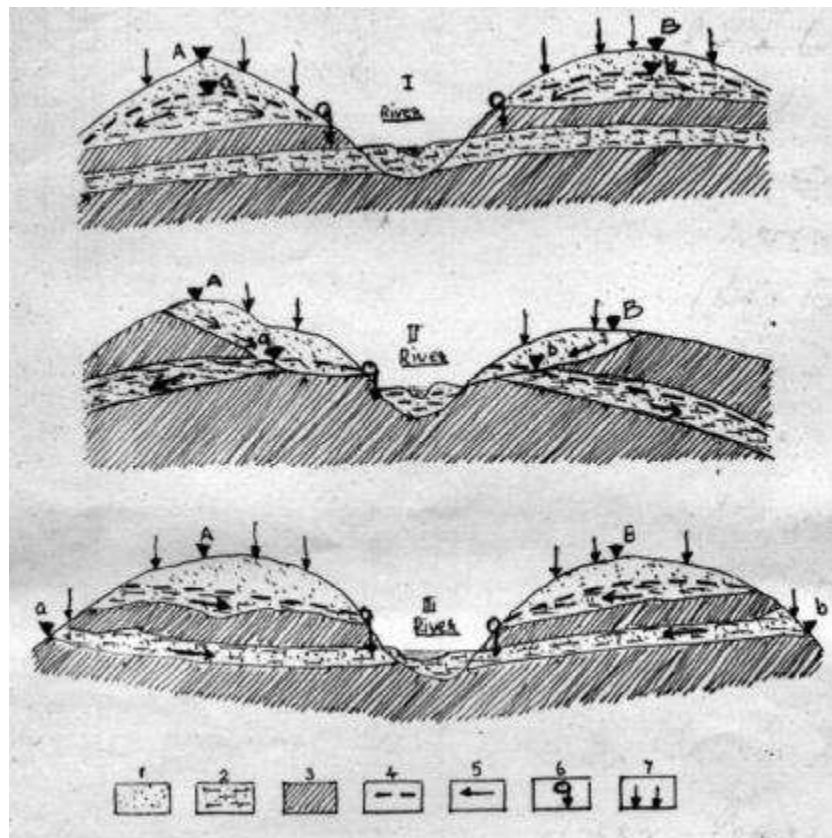


Physiographic map of the area around the December, 2, 1994

earth quake, Wadakkanchery, Kerala

Fig No: V-VI-I

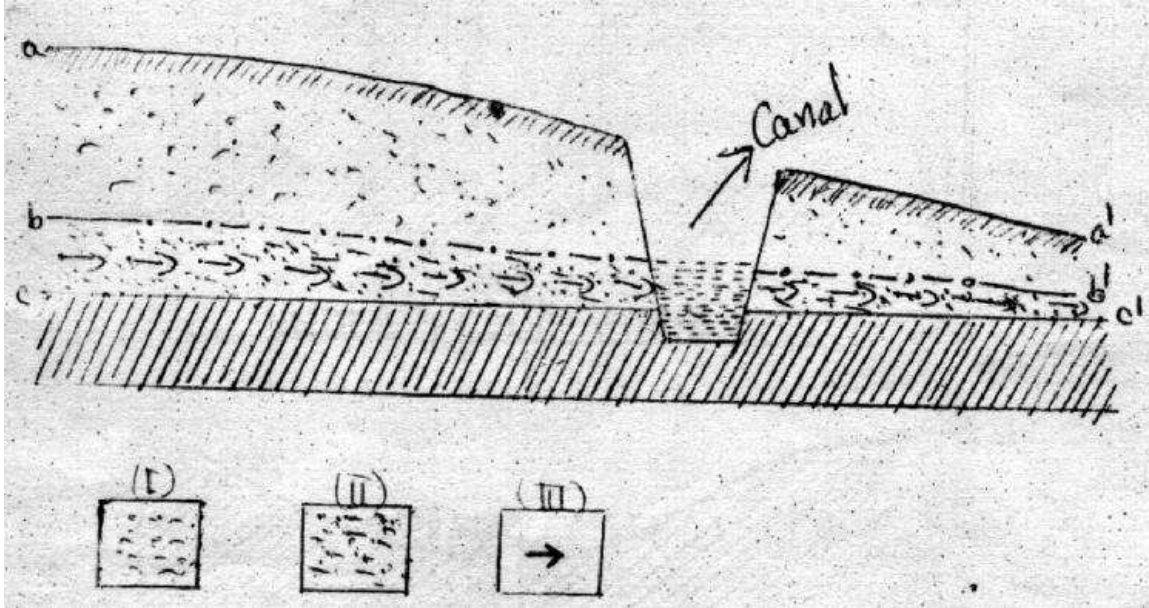
The relationship between the areas of surface and Underground Drainage Basins



**Fig I** :- Surface and underground drainage basins are Equivalent;  
**Fig II & III** :- Surface and underground drainage basins are not equivalent;  
**AB** : Surface runoff; ab:- ground water run off;  
1:- Sand, 2:-Water-bearing sand; 3:- Clay,  
4:-Ground water level; 5:- Stream directions;  
6:- Gravity string; 7:- Infiltration of rain water

**Fig No: VII**

Source: Fig No:-7, General Hydrogeology by P.P. Klimentov



- aa** : **Ground surface**  
**bb** : **Ground water table**  
**cc** : **Surface of impervious layer**  
  
**I** : **Residential soil, mostly in laterite**  
**II** : **Water bearing soil**



III : Water transit

Fig No: VII-IV-I

**UNDER-FLOW CHANNELS AND UNDER-FLOW CONDUITS**

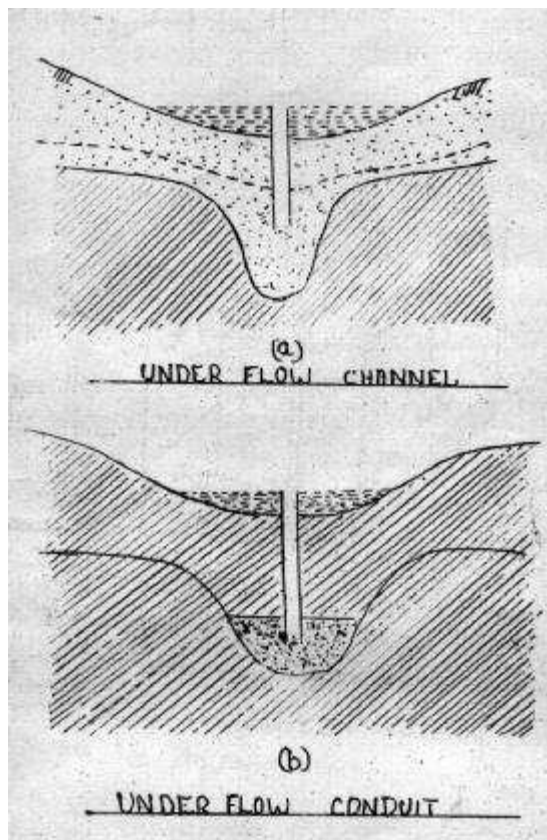
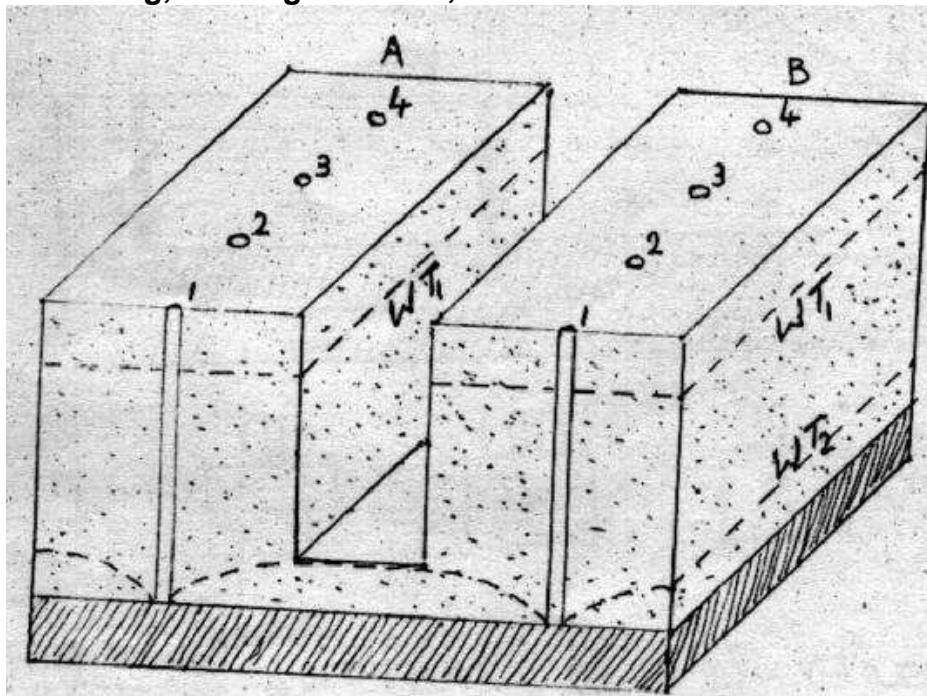


Fig No: VII-IV-II

Diagram showing, chainage of wells, in different locations



1, 2, 3, 4, are the wells

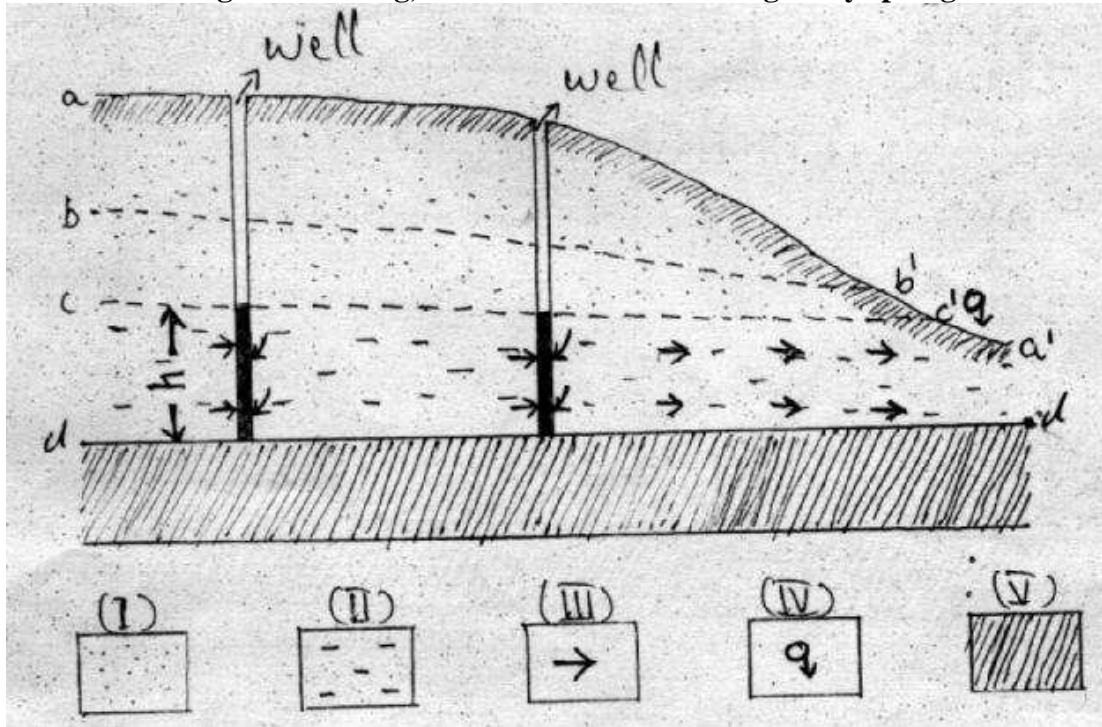
WT<sub>1</sub> is the position of water table in rainy season

WT<sub>2</sub> is the water table, lowered by pumping

A & B are the different locations of wells

Fig No:VII-VII-I-A

Diagram showing, wells on water transit of gravity spring



- $aa^1$  : Ground surface ;  $bb^1$  : Surface of capillary fringe  
 $cc^1$  : Ground water table;  $dd^1$ : Surface of aquitard  
 $ab$  : Zone of aeration ;  $bc$ : Zone of capillary saturation (capillary fringe);  
 $cd$ : Zone of saturation  
 $h$  : Height of ground water flow  
I : Local earth ; II: Water bearing soil  
III : Water transit; IV: Gravity spring  
V : Impervious layer

**Photo No. VIII - I - A**

Formulation of channels and sand-heaps on River-bed  
in Lekkidi – Perur Grama Panchayath area



**Photo No. VIII - I - B**

**Formulation of channels and sand-heaps on River-bed at  
Pallamthuruthy area in Lekkidi - Perur Grama Panchayath**



**Photo No. VIII - II - A**

**Area of sand deposits removed from the rocky layer on River-bed at  
Pallamthuruthy area in Lekkidi – Perur Grama Panchayath**



Photo No. XI - I - A

Emergence of sedges and shrubs on River-bed at  
Kalpathypuzha river junction in Bharathpuzha

