CHAPTER-I

INTRODUCTION
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Introduction

Water is the single most precious element for life on earth. Its availability is vital for the survival of mankind, satisfying basic human needs (i.e. health, food productions, energy generation, etc.) and the efficient functioning of ecosystems. Water resources have played a critical and vital role throughout the history of human civilization viz. Harappan, Mesopotamian, Egyptian, Chinese, etc. that had evolved and flourished in close proximity to water bodies especially around rivers. These water bodies were the principal source of drinking, irrigation and mode of transportation, which in turn attract more and more human population. As a result, the large number of mega-cities and gigantic industrial complexes of the world have developed on the bank of the major rivers and along the coastal belts in time and space.

Fresh water in spite of being a renewable resource has only finite reserves. It account only about 2.5% of global water (i.e. 97.5% salt water), of which 2.24% contained in polar ice cape (i.e. Antarctic, Greenland, etc.) mountain glaciers and deep groundwater. Where as only 0.26% of the global freshwater reserve is accessible for human uses.

Rivers which were once called the life line of cities or countries, now becoming fast disappearing many of them are already dead or contaminated beyond its self purification level, were no longer a source of safe drinking water, irrigation and industrial uses. For centuries rivers, streams, ponds and sea coasts are provided a convenient place to dump toxic wastes generated by various anthropogenic activities viz. mining, industrial, agricultural and
other human waste. Almost all the major rivers of the world are choking on chemical runoff and hazardous effluents. Instead of carrying life sustaining freshwater, they are little more than narrow sluggish streams of mining, urban, Industrial and agricultural solids and liquids toxic wastes. The lakes and ponds are facing contamination too and steadily disappearing.

Asian rivers are the most polluted in the world, with three times as many bacteria from human waste as the global average. Moreover, these rivers have 20 times more lead than those of industrialized countries (WHO – 2002). Furthermore, only 5 out of 55 rivers in Europe are considered pristine and about 60% of world is 227 large rivers are severally fragmented by dams, mining dumps, diversions, canal systems, etc., leading to the degradation of ecosystems. Whereas, all the 13 great river system in India are endangered.

About 2 million tons of waste is poured every day into rivers, lakes, ponds, streams, etc. while one tons of wastewater pollutes 8 liters of fresh water (world water Development report – 2002). According to this report, there is an estimated 1200 km$^3$ of polluted water world wide, which is more than the total amount contained in the world’s ten largest river basins at any given moment. Therefore, if pollution keeps pace with population growth, world will lose 18000 Km$^3$ of freshwater by 2050. Which are about 9 times the total amount countries currently use each year for irrigations.

The 21st century presents a new challenge to management, conservation and equitable distribution of this limited and fragile groundwater resource. The competition for groundwater has increased several folds during the later part of the last century, will continue to do so as shooting demand and fast deterioration of surface water bodies fail to
meet the needs of present growing world population and economic development. Today, much attention has been paid to groundwater resource because its portability and have huge reserves, which accounts 98% of accessible global fresh water supplies (i.e. estimated at 23,400,000 km$^3$ as compared with the 42,800 km$^3$ of rivers). Between 600 and 700 Km$^3$ are extracted each year, providing about 50% of the world’s drinking water supplies, 40% of industrial demands and 20% irrigated agriculture.

In India, groundwater supplies accounts about 90% of drinking water needs and over 50% of irrigated agriculture. Groundwater resources are depleting at an alarming rate especially in the southern parts of India. Of a total of 3400 blocks of groundwater available for use nationwide, 249 are already exploited beyond 100% and another 179 are exploited by more than 85%. In several states of India, the groundwater table has declined by more than 4 meters compared to the level in 1980, while in 206 districts it has plunged much more deeper level. The International Food Policy Research Institute projected that India’s water demand will go up by 50% over the next 20 years. By 2020, the demand will be over 900 cubic meters. The total withdrawal of groundwater in the country was estimated 607 billion cubic meters in 1951, will go up to 916 billion cubic meters by 2020. It is expostulated that the exploitation of groundwater resource will reach to danger levels by 2020. In fact, today at least 19 major cities of India have already been facing chronic water shortage.

During the last half of the 20$^{th}$ century, this finite and fragile natural resource are threatened by externalities such as population growth, industrialization, urbanization, massive mining activities economic expansion, agricultural intensification, changing life style, and other
anthropogenic activities resulted many ill-effects, including the lowering of water tables, salt water intrusion in coastal region, land subsidence, lower base flow of stream and climate change, will account for an estimated 20.0% of this increase in global water scarcity. Across the world, there is a growing concern about the deterioration of water quality and availability of safe drinking water. Today, water quality problems will be more serious than quantity. Water related diseases kill a child every eight seconds and are responsible for 80% of all illness and deaths in the developing world. Further, more than 3.4 million people die each year from disease related to contaminated drinking water and poor sanitations. Water vector-borne diseases also take a heavy toll; about a million people die from malaria each year and more than 200 million suffer from schistosomiasis known as belharzias. Every day 600 people, mostly children under the age of five die from diarrhoeal diseases (WHO-2002). This statistics clearly reveals the gravity of water related problems at present society is facing globally.

Of all the social and natural crises we human face, the water crisis is the one that lies at the heart of our survival and that of our planet earth (M. Koishiro – 2003). No region will be spared from the impact of this crisis that touches every facet of life, from the health of children to the ability of nations to secure food for their citizens. Today water scarcity emerges a global issue and has attracted world attentions. Even the theme of the world Environment Day – 2003: “Water, Two billion people are dying for it” was chosen by the United Nations Environment programme to highlight the centrality of water to human survival and sustainable development. Further more, United Nation had also declared year 2003, as an “International Year of Freshwater, 2003”.
It is anticipated that water rather than land availability will be the main constituent to agricultural production in the first half of this century. Further more, man will not die because of shortage of food, rather shortage of water viz. average grain yields doubled from 1.4 to 2.8 tons/hectares/crops during 1962 and 1996. It means that less than half the amount of available land is now required to grow the same amount of grain. Water resource is becoming a growing source of tension and fierce competition among nations, states, towns, and villages and between rich and poor, etc. with regard to distribution and sharing of this natural precious resource. Water is likely to play the same role in world economy in the 21st century, as oil had played in the 20th century and will be the source of conflicts world over to pose a major threat to human survival if proper preventive measures are not taken globally to conserve, manage and utilize it judiciously. Environmental scientists are speculating that the acute scarcity of water resource may force the powerful nations to wage new global war for the control of this fast depleting precious natural resource. In recent years, water riots are taking place in water deficit regions the world over.

In societies with the development, efficient utilization and effective management of their water resources should be the dominant strategy for economic growth and human survival. But in the recent years, over exploitation, unscientific management and use of this precious resource for various purposes almost invariably has created many ill effects in its wake, water logging and salinity in the case of agricultural use and other environmental problems of the various limits as a result of mining, industries and municipals use (Choubisa, et.al. 1995, Jain, et.al. 1996, 1997, Singh, et. al. 1996, Rao & Rao, 1990, Rao and Prasad, 1997).
The study area includes the Neyveli Lignite Field, which is the largest lignite deposits and associated with the biggest artesian basin in India and hardly lies 50 Km away from the East coast of India. Hence it is so called coastal aquifer and more popularly known as Neyveli Artesian Basin, named after hamlet, Neyveli, where it was first discovered. Neyveli artesian basin is the largest groundwater basin of South India and mainstay of Tamil Nadu’s economic development because major part of South India consist of hard rock viz. granite, gneisses and charnockite (i.e. Archaean and proterozoic Age) and also lacking perennial rivers.

The Neyveli lignite exploitation began in 1957, since then huge quantity of lignite excavated by removing thick pile of overburden material and massive depressurization of powerful confined aquifer below lignite seam. The impacts of opencast Neyveli Lignite Mining and associated industrial activities on the environment are complex: vast area of about 50 Sq. Km. has been devastated by strip mining, the groundwater level lowered by 60m, reversal of hydraulic regime, decrease of natural flows in artesian wells, contamination of groundwater and surface water, deterioration of soil quality, possibility of sea water intrusion, increasing pumping costs, deterioration of ambient air quality by large scale emission of flyash, sulfur dioxide (SO₂), carbon dioxide (CO₂), Nitrous oxides (NOₓ), etc. in the atmosphere from lignite fire plants and fine particles from naked overburden material and exposed flyash ponds. Wherein, principal effects of hazardous waste on the environment are the contamination of groundwater resource. Which jeopardize human health and disturbed the ecological balance.
An attempt has been made here to assess and evaluate the impact of lignite opencast mining and associated industries activities on groundwater in and around Neyveli lignite mines.

**Location of Study Area**

The study area is Neyvli lignite field and its surrounding regions, which is located 200 Km south of port city of Chennai (Fig.1), in the Cuddalore district of Tamil Nadu state, India. The Gadilam River in the North and Vellar River bound the area in the south, in the east by Bay of Bengal and west by high ground of Archaean rock (i.e. Charnockite and gneisses). The Geographical co-ordinate of the study area lies between latitude $11^\circ 25'$-11$^\circ 45'$N and longitude $79^020'$ to $79^045'$E. The area falls in the survey of India’s Toposheet No. 58M/6, 58M/7, 58M/10 and 58M/11. The study area cover is about 990 sq. Km. comprising parts of Cuddalore, Panruti, Vridhachalam and Chidambaram taluks of the Cuddalore district.

The area has a good network of railways and roads. Cuddalore town, headquarter of Cuddalore district and the other important towns in the area are Chidambaram, Panruti, Virdhachalam, Ulundurpettai and Neyevli. These towns are well connected with Chennai Metropolis by a railways and metalled roads. Most of the villages are connected either by metalled or unmetalled motorable roads.
Fig. 1: Location map of the study area
Previous Work

The study area was first studied and mapped by Blandford of the Geological Survey of India (G.S.I., 1865). King and Oldham mapped the areas adjoining the lignite field in the early thirties of the 20th century. Later Cretaceous and Tertiary sedimentary rocks in the area were mapped by Krishnan, Jacob & Argyaswamy of G.S.I. during 1941-45. The detail geological studies of Neyveli lignite area were carried out by the Jacob and Jacob (1950), Rao, 1955, Krishnan, 1960, Ramanujam, 1966 & 68, Subramaniam, 1969, Deb, et.al.1973, & Venkatachala, 1973).

The erstwhile groundwater wing of the Geological Survey of India (G.S.I.) has successfully carried out detailed hydrogeological studies through multi-pumping test programme to understand the prevailing hydrogeological conditions and aquifer characteristics in order to assess the feasibility of groundwater control for safe and economic mining of the lignite deposits during 1954-59. Kailasam, et.al. (1963 & 1965) had done detailed geophysical investigations of the Tertiary sedimentary basin of east coast of India, to decipher the sub-surface configurations. The Geological Survey of India (1971) has also conducted study on the impact of large scale pumping of groundwater on groundwater regime in and around the Neyveli Lignite Field.

Systematic and detail hydrogeological survey were taken up by the scientists of Central Groundwater Board (CGWB) in 1981-82, 1986-87 & 1995-96 to study the effects of large scale pumping on groundwater in and around lignite mining area. The systematic geological and geophysical investigations in the Neyveli basin was carried out by Oil and Natural Gas commission (ONGC) for the search of hydrocarbons and followed by
drilling operations. The State Groundwater Department of Tamil Nadu also monitored the long-term effect of groundwater pumping on hydrogeological regime, possibility of seawater intrusion and so on. The Neyveli Lignite Corporation (NLC) has also been monitoring salt-water intrusion, depletion of water level, Neyveli groundwater budget and done comprehensive work on geological and hydrogeology of the Neyveli Artesian Basin. Regional groundwater modeling of the Neyveli Basin has been done jointly by National Geophysical Research Institute (NGRI), Hyderabad (1986) and Neyveli Lignite Corporation in 1986 and later by former East Germany (GDR) on behalf of Neyveli Lignite Corporation on the basis of contact with VEB Industrie-consult Berlin-GDR by IBK consulting, Braunkohlenkom – binat Senftenberg in co-operation with the University of Technology of Dresden, 1989.

**Aims and Objectives**

An attempt has been made to assess and evaluate the present status of groundwater and surface water quality, groundwater resource status, aquifer system and their disruption, effects on groundwater budget and groundwater regime, and effects & extents of seawater intrusion, if any. Water and Land resources are under deep stress due to massive opencast lignite mining and associated industrial activities, burgeoning population growth and intensive agricultural activities especially water intensive crops like paddy and sugarcane in the investigated area. Groundwater is the only source of water available for various utilities like drinking, industrial, irrigation and other purposes in the Neyveli Lignite Field. Wherein, no major river lies near by study area except two minor seasonal rivers (i.e. Vellar and Gadilam)
The study area lies in the highly water stress region of India, where war of water sharing among the southern states of India is deepening year after year. The investigated area consists of two gigantic opencast lignite mines, three pit head thermal power plants, urea plant, briquatting and carbonization plant are spread over an area of about 150 sq. Km. Over the last 40 years, excessive depressurization of confined and semi-confined aquifers, dewatering of water table aquifer, massive removal and dumping of overburden material, large scale discharge of mine water, industrial effluents and flyash ponds overflows into natural and artificial drainage, disposal of mines waste and fly ash in the Neyveli region may cause serious threat to groundwater resource and ecosystem. The mining and industrial waste containing various toxic elements that may inter the food chain and thus adversely affect the human health.

Keeping in mind the above aspects, an attempts has been made to synthesis the existing data of various Government agencies like Neyveli Lignite Corporation (NLC), Central Groundwater Board (CGWB) and State Groundwater Board (S.G.W.B.), Geological Survey of India (G.S.I.), etc. and the data generated in the present investigation to get an insight into the hydrogeological and hydrogeochemical behaviors of groundwater, extent of groundwater and surface water pollution, groundwater regime, possibility of sea water intrusion, evaluation of aquifer system and their disruption, etc. in and around the Neyveli Lignite Field are included and synthesized in partial fulfillment of this Ph.D. progaramme.
The present study in and around the Neyveli lignite area includes the following aspects:

1. Mapping and delineation of major water bearing zones.
2. To study the extent and sources of groundwater and surface water pollution.
3. To study the framework of aquifer disposition and their interrelationship.
4. To demarcate the area of groundwater recharge and discharge.
5. To study the hydrogeochemical characters of surface and groundwater in order to determine the water quality status in the area.
6. To study the effects of massive depressurization of confined aquifer on groundwater regime.
7. To study the possibility of seawater intrusion.